

# The Blast Furnace and Steel Plant

## Editorial Advisory Board

H. J. Freyn  
Barton R. Shover  
F. F. Slick  
Dr. J. S. Unger  
F. E. Kling

Editor—DON N. WATKINS

Managing Editor—CHARLES LONGENECKER

## Editorial Advisory Board

Kenneth B. Lewis  
J. S. Lochhead  
Theodore E. See  
F. H. McClelland  
D. L. Mathias

Volume XVI

FEBRUARY, 1928

Number 2

## CONTENTS

|                                                                                                                                                                                                                    |     |                                                                                                                                                                                                 |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Desulphurizing in the Blast Furnace.....                                                                                                                                                                           | 233 | Practice in Making Open-Hearth Steel.....                                                                                                                                                       | 258 |
| A Condensation of the Findings of Kinney, Goldberg and Michel to Which Has Been Added Data Secured by the Authors—Probable Reactions in Sulphur Elimination Explained<br>By C. H. HERTY, Jr. and J. M. GAINES, Jr. |     | Suggestions Are Offered by a Man of Practical Experience as to the Effects of Iron Oxide, Manganese and Silicon—Charge Considered in General<br>By C. W. VEACH                                  |     |
| Promotions at Jones & Laughlin.....                                                                                                                                                                                | 238 | Technology Problems of the Steel Industry....                                                                                                                                                   | 261 |
| T. M. Girdler Becomes President of the Corporation Succeeding Charles A. Fisher—Other Officials Advanced—Policy of Organization to be Maintained                                                                   |     | The Beneficiation of Iron Ores—The Selection and Cleaning of Coal—Utilization of Mine Wastes—Study of Coking Properties—By-Products of Coke Production<br>By WILLIAM A. FORBES                  |     |
| A Newly Constructed Seamless Tube Mill.....                                                                                                                                                                        | 240 | The Power Plant—                                                                                                                                                                                |     |
| A Description Bringing Out Important New Features in the Design of a Large Roll Type Piercing Mill—Entirely Motor Driven—Rapid and Accurate in Production<br>By CHARLES A. COLGATE                                 |     | Developments in Steam Generation.....                                                                                                                                                           | 266 |
| The Dressing of Rolls by Grinding.....                                                                                                                                                                             | 242 | A Review of the Progress Made in the Methods and Apparatus for Generating Steam—High Steam Pressures—Air Preheating and Fuels<br>By GEORGE T. LADD                                              |     |
| Touching on the History of Grinding Rolls, the Advantages of This Method of Roll Dressing Are Fully and Clearly Outlined—Special Grinding Operation in Forming Rolls<br>By HAROLD J. PRATT                         |     | Power and Heating Needs in Power Plants.....                                                                                                                                                    | 270 |
| Sheet Steel for Automobile Bodies.....                                                                                                                                                                             | 245 | Of Ever Increasing Importance Is the Question as to Whether It Is More Economical to Purchase Power or to Generate It in the Plant—This Question Is Discussed by the Author<br>By C. L. HUBBARD |     |
| A Detailed Non-Technical Discussion of the Importance of and the Processes Involved in the Manufacture of Automobile Body Sheet Steels<br>"AUTOSHEET"                                                              |     | An Inspiration .....                                                                                                                                                                            | 231 |
| The Evolution of the Wide Strip Mill.....                                                                                                                                                                          | 249 | With the Equipment Manufacturers.....                                                                                                                                                           | 274 |
| An Engineer Intimately Acquainted with the History of Strip Mills Relates the Successive Developments in the Design of Mills and in the Practice of Rolling<br>By STEPHEN BADLAM                                   |     | Trade Notes .....                                                                                                                                                                               | 276 |
| Developments in Metallurgy During 1927.....                                                                                                                                                                        | 255 | News of the Plants .....                                                                                                                                                                        | 279 |
| Among Topics Considered Are: Ferrous Metallurgy, Centrifugal Casting, Silicon Alloys, Welding, Application of X-Rays, Chromium Plating, and Non-Ferrous Metallurgy<br>By JAMES SILBERSTEIN, Ph.D.                  |     | The Open Hearth.....                                                                                                                                                                            | 280 |
|                                                                                                                                                                                                                    |     | Trade Publications .....                                                                                                                                                                        | 284 |
|                                                                                                                                                                                                                    |     | Coming Meetings .....                                                                                                                                                                           | 284 |
|                                                                                                                                                                                                                    |     | The Steel Plant Brick Mason.....                                                                                                                                                                | 287 |
|                                                                                                                                                                                                                    |     | Safety First in the Steel Plant.....                                                                                                                                                            | 292 |

Published the first of each month by Steel Publications Inc.

Main Office—Thaw Building, 108 Smithfield Street, Pittsburgh, Pa.

DON N. WATKINS, President

D. S. WATKINS, Vice President

M. M. ZEDER, Secy.-Treas.

### EASTERN MANAGER

ROBERT E. POWELL  
29 West Thirty-fourth Street  
New York  
Phone—Wisconsin 5459

### WESTERN MANAGER

GEO. P. GRANT  
105 West Monroe Street  
Chicago, Ill.  
Phone—Randolph 3264

Subscription Price:—In the United States, \$2 per year; Canada, \$2.50; all other countries, \$3.50. Single Copy 25 cents.  
Entered as second-class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

# The Blast Furnace *and* Steel Plant

Vol. XVI

PITTSBURGH, PA., FEBRUARY, 1928

No. 2



## An Inspiration

ABRAHAM Lincoln's life is an everlasting source of inspiration. Born amid the most humble circumstances, he rose above them and made a place for himself. He did not ask to be given "opportunity," he made it. And he made it by hard work and persistency. When in these days, with our manifold advantages, we hear the plaint of lack of opportunity it dwindles to insignificance when compared to Lincoln's destitution. With an exceedingly meagre education he gave

the world, in his Gettysburg address, a classic that is now spread upon a tablet on the walls of Oxford College.

No matter how chaotic conditions might be he confronted them absolutely unperturbed. The responsibilities he carried were not those which concerned only an individual or an industry, but they were the deciding issues of a nation—a nation in one of its darkest periods. Our industrial leaders can look to Lincoln's exemplary behavior for inspiration when affairs are disturbed and uncertain.

Lincoln's ability to think clearly and with no bias was a tremendous asset to him. It has likewise been a predominating asset to practically every man who has risen to prominence in the steel industry. Captain "Bill" Jones—a patriarch in steel manufacture—was so gifted, as was also Judge Gary.

Lincoln was an optimist—a real optimist. He embodied optimism of the highest type. It is easy enough to be optimistic when one is surrounded by every comfort and luxury, but it requires a man of metal to radiate optimism when disaster is impending on every hand.

Furthermore Lincoln's observations were correct and he knew how to interpret them.

# Desulphurizing in the Blast Furnace

A Condensation of the Findings of Kinney, Goldberg and Michel  
to Which Has been Added Data Secured by the Authors—  
Probable Reactions in Sulphur Elimination Explained

By C. H. HERTY, Jr.\* and J. M. GAINES, Jr.†

**K**NOWLEDGE of the reactions which take place, and of the factors governing them, in the hearth of the iron blast furnace is accumulating slowly. By far the most thorough and illuminating contribution of recent date is that of Kinney.<sup>1</sup> By taking samples of materials from within the furnace at various elevations from the stock-line to just above the tuyeres he has shown that the metal at this lower level may contain 87 per cent of the silicon, 200 per cent of the manganese, and from 300 to 400 per cent of the sulphur which will be present in the iron at cast. In other words, the critical region of the furnace for determining the final concentration of manganese and sulphur is below the tuyere line. This means that most of the work must be done by the slag layer through which the metal must pass.

The writers have been attempting for some time to formulate a theory which will explain, from a physico-chemical viewpoint, the various phenomena occurring in the lower part of the furnace. Attention thus far has been directed almost entirely on the sulphur question, and the theory relating to it will be presented, together with such data in its support as have been gathered from time to time.

## Sulphur in the Furnace

The critical region for sulphur is between the tuyeres and the top of the metal collected in the crucible. In this zone the iron, in a spray or mist, consisting of particles of varying size, drops through the slag, losing sulphur and tending to come to equilibrium with the slag in respect to other metalloids. At the same time, slag is dropping down over the incandescent coke, and, in so doing, it is being deoxidized in preparation for its work of desulphurization, to be explained. In other words, two actions are taking place consecutively, the first dependent on the second for its efficient operation.

## Reactions During Desulphurization

It will be appropriate here to mention the reactions by which desulphurization proceeds. In the first place the slag, containing unreduced oxide, comes in contact with hot coke, and the FeO is partly reduced, as follows:



The fact that considerable heat is absorbed in the reduction of FeO by this reaction means that as the temperature is raised the equilibrium will shift toward the right—that is to say, the direction of reduction of

FeO. The equilibrium constant expresses the relation existing between the concentrations of the products of reaction and those of the initial substances entering into it when equilibrium is reached. For equation (A) the constant would be expressed:

$$(B) \quad K_{\text{Fe}} = \frac{(\text{Fe})(\text{CO})}{(\text{FeO})(\text{C})}$$

In other words, at equilibrium, the product of the concentrations of the substances produced by the reaction divided by the product of the concentrations of the substances entering into the reaction is a constant. This constant will, however, vary with the temperature. For an increase in temperature it will increase for those reactions which absorb heat and decrease for those which evolve heat.

In the case here considered, it has been stated that the constant  $K_{\text{Fe}}$  increases with temperature. Further, this increase can only be caused by a decrease in (FeO). The reason for this is that the three other terms, (Fe), (CO), and (C) are essentially constant for a furnace operating under normal conditions; (Fe) and (C) can not vary, because they are present as separate phases—namely, metal and coke. And since the per cent CO in bosh gas is nearly always the theoretical quantity, it will exert a constant pressure in the reaction unless the blast pressure varies. By incorporating these terms into the constant, we may now write

$$K'_{\text{Fe}} = \frac{1}{(\text{FeO})}$$

The reduction of MnO takes place in a similar manner and obeys the same laws. In this case we have the reaction



and the equilibrium constant:

$$K_{\text{Mn}} = \frac{(\text{Mn})(\text{CO})}{(\text{MnO})(\text{C})}$$

It is apparent that manganese reduction requires a great deal more heat than does that of iron. For this reason the equilibrium will be even more sensitive to temperature changes, than in the case of the reduction of FeO. Here again we may simplify the expression by noting that (CO) and (C) are constant as before. However, (Mn) is not constant, and therefore the equation in its modified form must be written

$$(D) \quad K'_{\text{Mn}} = \frac{(\text{Mn})}{(\text{MnO})}$$

The foregoing serves to explain from a physico-chemical viewpoint why a high temperature causes a well-deoxidized slag, and why a cold cinder will be high in unreduced oxides of iron and manganese.

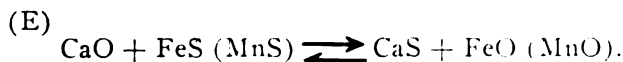
\*Physical chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines, formerly research associate, Massachusetts Institute of Technology, School of Chemical Engineering Practice, Bethlehem Steel Company, Lackawanna, N. Y.

†Assistant physical chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines, formerly assistant director, Buffalo Station, Massachusetts Institute of Technology, School of Chemical Engineering Practice, Bethlehem Steel Company, Lackawanna, N. Y.

After being deoxidized by the coke and falling into the crucible, the slag is ready to receive the metal and to do its work of scrubbing out the sulphur. Let us consider a drop of iron containing sulphur as FeS and MnS. Both sulphides are soluble in slag and will tend to pass from metal to slag as the drop falls through. If the drop were to fall through an infinitely thick slag layer the sulphides would continue to be absorbed until equilibrium was reached—that is, the ratio

$$\frac{\text{FeS in slag}}{\text{FeS in metal}}$$

would approach a constant quantity, known as the distribution ratio. Such is not the case, however, because of the brief contact of the drop with the slag and because the excess base, CaO, in the slag reacts with the sulphides as follows:



This results in a lowering of the concentrations of FeS and MnS in the slag and consequently enables more sulphur from the iron to be taken into the slag. The more rapid the conversion to CaS in the slag phase the greater will be the tendency for solution from the metal; consequently the greater will be the amount of desulphurization. A glance at equation (E) will show that the speed of CaS formation will increase with the amount of available base present and with the concentration of the iron or manganese sulphide. If a large amount of CaS is already present, the speed will be low. Furthermore, the action of the oxides of iron and manganese is to throw the reaction toward the left (as written above). In fact, the key to the elimination process is the relative oxidation of the slag. If FeO and MnO be low, as with a hot hearth, sulphur is readily eliminated, whereas with high content of oxides in the slag the amount of sulphur recovered will be small. In this way the marked effect of temperature on the sulphur content of the metal may be explained.

#### Findings of Goldberg<sup>2</sup>

A detailed study of the relation between the three quantities, iron oxide in the slag, sulphur in the metal,

and temperature at the tuyere line has been made by Goldberg. His results may be summarized as follows:

1—For a given furnace or for several furnaces working similarly there is a direct relation between the average temperature at the tuyeres and the average concentration of sulphur in the metal. This is shown in Fig. 1. (Two points have been added by the writers.)

2—Similarly, the iron oxide (FeO) content of the slags is controlled largely, for normal working, by the temperature in the tuyere zone. Fig. 2 shows this graphically for slags taken at flush from two furnaces. In each case the FeO content of the first slag from the monkey has been plotted against the temperature of the tuyere or tuyeres right above the monkey. In this way variation caused by hot or cold spots is taken into account. The dotted line drawn through the upper points shows the possible range of experimental accuracy. These may be due to such irregularities in working as slight slips.

3—In a single furnace during the period between casts variations in temperature around the tuyere zone have been noted, and these have been shown to correspond to variations in the sulphur content of the metal during the following cast. When the furnace was working hot in front, the first metal was found to contain the lowest amount of sulphur, etc. The results on three of Goldberg's casts are shown in Figs. 3, 4, and 5. The first (Fig. 3) is from a basic furnace and shows a case where the sulphur is low during the middle of the cast. At the beginning of the cast it was high, at 0.097 per cent, with the average temperature of 1,395 deg. C. in tuyeres 2 and 10. Further back at tuyeres 3 and 9 the temperature had risen to 1,540 deg. C. and the sulphur dropped to 0.075 per cent in the second ladle and to 0.066 per cent in the third. The back of the furnace was even colder than the front and reached the very low value of 1,325 deg. C. at tuyere 6. Meanwhile the sulphur has started to rise and shows 0.078 per cent in the fourth ladle. In the fifth, and last, ladle there is a drop, in spite of the lower temperature. It is impossible to assign a reason for this other than experimental error.

A similar case, but with sulphur highest in the middle of the cast is shown in Fig. 4. This cast

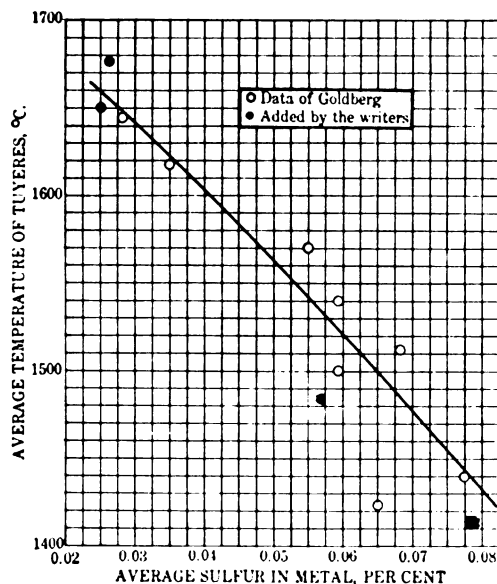


Fig. 1—Effect of tuyere temperature on amount of sulfur in the metal

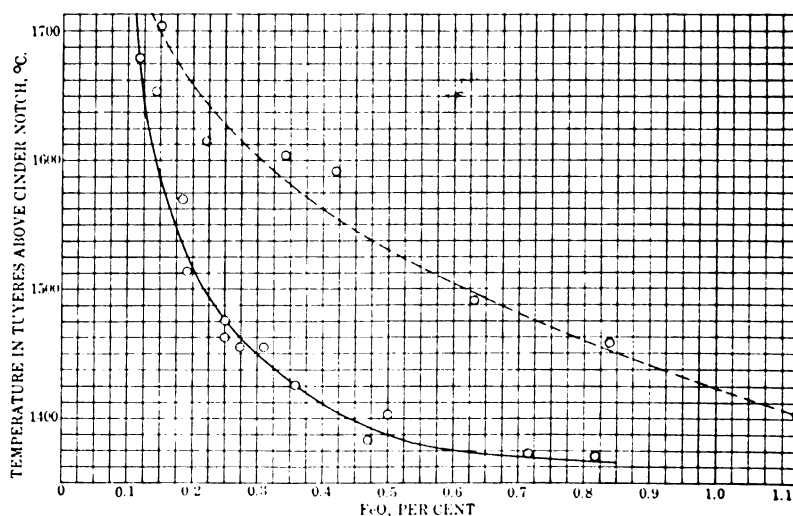


Fig. 2—Effect of temperature on amount of FeO in flush slags



was observed on the same furnace as the foregoing example about two weeks later. The third example (Fig. 5) is from a foundry furnace, and shows the condition where the tuyeres are all working at nearly uniform temperature with resultant uniformity in the sulphur content of the metal. The slight apparent variations, however, are definitely in line with the general conclusions.

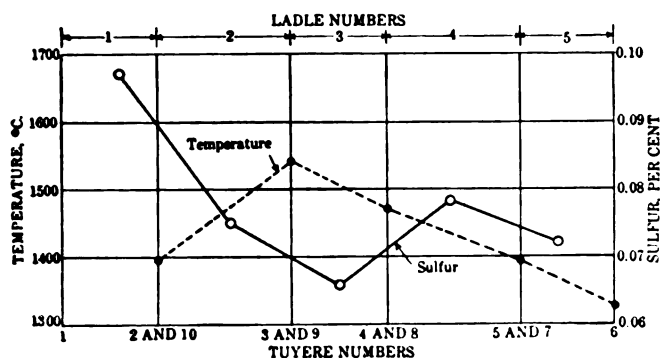


Fig 3 - Variation in temperature at the tuyeres and in sulfur in the metal for a cast of basic iron.

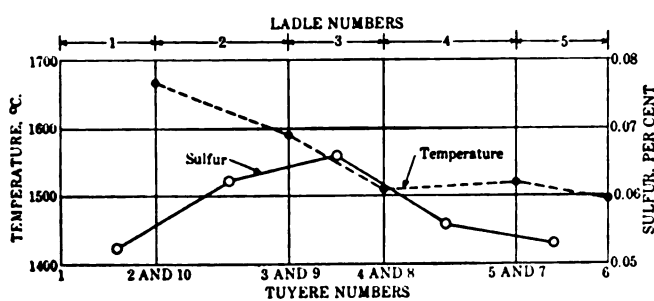


Fig 4 - Variation in temperature at the tuyeres and in sulfur in the metal for a cast of basic iron.

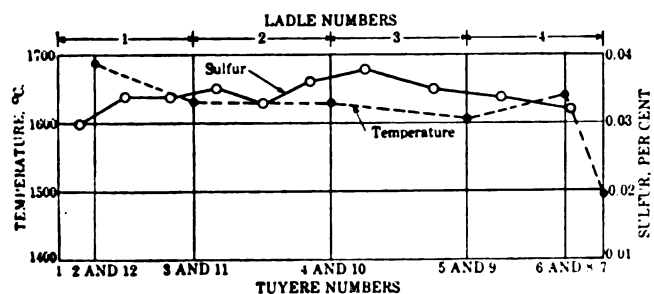
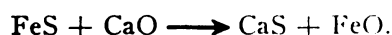


Fig 5 - Variation in temperature at the tuyeres and in sulfur in the metal for a cast of foundry iron.

These observations clearly indicate what an important factor the temperature is in the desulphurizing process. They further show beyond doubt that the reason for this influence is the greater reduction of FeO in the slag possible at higher temperatures and the consequent speeding up of the reaction



#### Findings of Michel

Michel<sup>3</sup> has also observed variations in silicon, manganese, and sulphur during a cast and has found these changes to correspond with fluctuation in metal temperature. He assigns as a reason the dropping of cold stock into the hearth during casting. He has also shown that the total carbon content of the iron depends

upon the silicon content and on the casting temperature for a given type of charge.

#### Factors in Sulphur Elimination

It is evident that the first requirement for sulphur elimination is therefore proper chemical condition of the slag. A second factor of primary importance, not so widely recognized, is the proper means of absorbing sulphides from metal to slag. Bearing in mind the fact that the desulphurizing reactions take place at the slag-metal surface and in the slag itself, and not in the metal phase, it becomes important that sulphur be transferred from the metal to slag, in order for reaction to proceed. The process is simply one of absorption, or scrubbing, similar in principle to that which removes light oil from coke-oven gas.

#### Effect of First Contact of Iron with Slag

Globules of high-sulphur iron come in contact first with freshly deoxidized, low-sulphur slag, at the top of the slag layer. During their passage through the scrubbing medium these globules will give up sulphur to the slag according to the reactions outlined. At the bottom of the slag layer the condition will be the reverse of that at the top—namely, high sulphur in the slag and low sulphur in the metal. Evidence of this increase in the percentage of sulphur in the slag is easily obtained by comparing analyses at flush and at cast. Some examples<sup>4</sup> are given in Table I, in which the FeO and MnO are also given.

TABLE I—Sulphur at Flush and Cast.

| Cast No. | S, per cent |            |      | FeO, per cent |            |      | MnO, per cent |            |      |
|----------|-------------|------------|------|---------------|------------|------|---------------|------------|------|
|          | First flush | Sec. flush | Cast | First flush   | Sec. flush | Cast | First flush   | Sec. flush | Cast |
| A ..     | 1.78        | 1.62       | 2.14 | 0.32          | 0.20       | 0.19 | 1.91          | 1.13       | 1.05 |
| B ..     | 1.57        | 1.46       | 1.93 | 0.39          | 0.79       | 0.41 | 1.74          | 2.50       | 1.48 |
| C ..     | 1.58        | 1.59       | 1.90 | 0.36          | 0.47       | 0.32 | 1.52          | 1.99       | 1.10 |

Each analysis given represents the average of several samples—generally two or three during the flush and cast. It is interesting to note that while there is an increase in sulphur concentration in the slag at cast over that at the flushes, as would be expected, the first flush contains a higher proportion of sulphur than the second. This is due primarily to the fact that at the time of the first flush (one hour before cast) the level of slag is several feet above the cinder notch. Consequently the slag removed at this time is not the fresh slag from the top of the slag layer, but slag which has been in the furnace for some time. At the second flush, which comes, in this case, from 10 to 15 minutes later, the slag which has just dropped into the crucible, and which has therefore less sulphur than the preceding flush, is tapped out. From this it is evident, also, that whether the first or second flush shows the higher sulphur content will depend in great part on the particular flushing schedule followed.

The average increase in sulphur in the slag from second flush to cast is 0.43 per cent. If a slag volume of 50 per cent of the weight of iron be assumed, this value means that about 0.215 per cent of sulphur has been removed from the metal. In other words the metal, at the time of entering the slag, contained some 0.25 to 0.30 per cent of sulphur. Kinney<sup>5</sup> finds as high as 0.17 per cent at the tuyeres and Sweetser<sup>6</sup> reports values from 0.020 to 0.101 per cent. It is probable that in calculating from slag sulphur concentrations, error

is introduced through absorption of sulphur directly from the coke.

It will be noticed that FeO and MnO have decreased considerably in every case. This is due doubtless to reaction of the slag with coke or with silicon in the iron.

In this connection Wüst<sup>7</sup> has lately published data showing how the concentrations of metalloids in the iron change in passing through the slag. This he determined by analyzing "washed iron," or shot contained in flush slags, and comparing it with the pig iron in the succeeding cast. His average of 16 determinations follows (Table II):

TABLE II  
Comparative Analyses of Washed Iron and Pig Iron.

| Metalloid      | Per cent in washed iron | Per cent in pig iron | Per cent difference | Percentage difference |
|----------------|-------------------------|----------------------|---------------------|-----------------------|
| Silicon .....  | 0.945                   | 0.747                | -0.198              | -20.8                 |
| Manganese .... | 0.720                   | 0.618                | -0.102              | -14.2                 |
| Phosphorus ..  | 0.134                   | 0.133                | -0.001              | - 0.75                |
| Sulphur .....  | 0.0322                  | 0.0360               | +0.0038             | +11.8                 |
| Carbon .....   | 4.49                    | 4.50                 | -0.01               | + 0.22                |

The drop in silicon and manganese is due, according to Wüst, to oxidation by FeO in the slag, the latter being formed in considerable quantities in front of the tuyeres.

It will be noted that these results seem to be practically in contradiction to those in Table I. Dr. Wüst shows that oxidation of manganese is taking place, whereas in Table I it is evident that reduction of MnO occurs in this region. As pointed out previously this reaction is extremely sensitive to temperature changes, and, since Dr. Wüst states that his data are taken from a furnace operating on a "stiff" slag (a possible indicator of a cold hearth) it is possible that a difference in temperature may have caused this difference in the behavior of the manganese.

In regard to the change in sulphur content, the writers do not believe that the iron picks up sulphur during its passage through the slag except under extraordinary conditions. They would prefer to interpret the apparent increase in the following manner: Globules of shot taken from the slag at the monkeys have to fall a considerable distance through the slag layer before arriving at the level of the monkey. This distance will vary, of course, at different times depending on the volumes of metal and slag present. In addition to this time for contact with slag, there must also be considered the violent scrubbing action taking place while the slag flows out of the cinder notch and along the runner to the point where it is sampled. It is entirely possible that the sum of these effects would produce a greater amount of desulphurization than would the ordinary process in which the drop merely falls by gravity through the slag layer. The result would be lower sulphur in the shot than in the pig iron.

One rather important conclusion as to desulphurization may be drawn from Dr. Wüst's statements. That is that by far the major part of sulphur removal occurs while the metal is passing down through the slag, and a negligible part while slag and metal exist as contiguous layers in the bottom of the crucible. If this were not true one should not find so nearly the same sulphur content in pig iron and in washed iron, or shot.

This conclusion is also supported by Goldberg's results. If there were appreciable desulphurization

between the layers of slag and metal the variations in desulphurization caused by variation in tuyere temperature would have been equalized during the "period of quiescence" in the crucible. It is significant that whereas variations in metal temperature are obscured during this time, variations in the concentrations of sulphur are not.

### What Goes On in the Absorbing Zone

The physical structure of this absorbing zone may be described by saying that it is a coke-packed tower. The coke floats on the iron to a depth determined by furnace lines, weight of stock, and blast pressure. In the tuyere, or combustion space, droplets of slag and metal will trickle down over the coke in irregular paths and will probably be blown about and broken up to a certain extent by the blast. On reaching the slag layer, the metal droplet is retarded but continues to fall through the liquid slag, striking against the pieces of coke immersed therein, until it reaches the iron layer at the bottom of the furnace.

During this period of passage of the metal through the slag, the process of absorption of sulphur from the former by the latter takes place. The fundamental equation<sup>8</sup> for this process is

$$(F) \quad \frac{dW}{d\theta} = kA (C - C_0)$$

in which

$$\frac{dW}{d\theta} = \text{pounds absorbed per minute,}$$

A = square feet of surface for absorption,

C = average concentration of material being removed,

C<sub>0</sub> = average equilibrium concentration of this material at the interface (i.e., slag-metal surface),

k = a constant, pounds, per minute per square foot per unit difference in concentration.

The area of the globules of iron in the slag at any given time—or at all times—is denoted by A. Evaluation of this quantity involves knowledge of the size and number of the individual drops. Field and Royster<sup>9</sup> have calculated, by means of Stokes' law, from the content of metallic iron in average slags that the average drop is 0.112 in. in diameter, and that its rate of fall is 0.194 in. per second, or about a foot per minute. Evidently the smaller the particles of iron the greater will be the amount of desulphurization, other things being equal, for with small particles not only will A become greater per unit weight of iron, but also the rate of fall through the slag will be slower, thus increasing the time of contact.

Besides the absorbing area, the time of contact between the metal drop and the slag layer is also a controlling factor in absorption. This depends first upon the rate of fall which in turn is a function of the densities of slag and metal, slag viscosity, and particle size. The time of contact will also be proportional to the depth of the slag layer. As the drop falls, it approaches equilibrium with the slag, but most probably does not attain it, and therefore the rate of transfer of sulphur becomes less. For this reason the amount of desulphurization is not directly proportional to time of contact—the rate drops with increasing time of contact. However, there is certainly a possibility that, by making the crucible of such a shape that the same

amount of slag would make a deeper layer, greater desulphurization might be accomplished.

The term  $C - C_0$  represents the driving force for absorption. Suppose that a given slag will, if given an infinite time, remove sulphur from the iron down to 0.010 per cent: This is the equilibrium concentration,  $C_0$ . At some time, say at the start, of the absorbing process, the sulphur concentration,  $C$ , might be 0.150 per cent. The driving force,  $C - C_0$ , would then be  $0.150 - 0.010 = 0.140$  per cent. At the end of the fall through the slag,  $C$  may have dropped to 0.050 per cent. In this case the driving force would be  $0.050 - 0.010 = 0.040$  per cent of sulphur. In other words, there is still a tendency toward desulphurization and the process would proceed, provided that there is more slag below this point. The rate, however, would have decreased from its initial value by the ratio  $0.040/0.140$ , or about a 72 per cent reduction.

Here again two consecutive processes are necessary to cause the transfer of sulphur from metal to its final form as CaS in the slag—namely, (1) diffusion of FeS and MnS to the slag-metal boundary; and (2) the reaction at this boundary and in the slag between these sulphides and lime. Obviously, the elimination will proceed at the speed of the slower of the two processes. It is impossible to say which one is the slower, but it seems probable that that one which involves two phases—that is, the diffusion would require more time than the reaction in the homogeneous slag phase.

The coefficient of absorption,  $k$ , is necessary to take into account the physical make-up of the system, and to include the effects of other variables not contained in the fundamental equation (F). In general, it is a constant for a given system at a definite temperature.

Variables which may be considered as affecting the value of  $k$  are: (a) speed of fall of the drop, which affects the thickness of the interfacial film between slag and metal; (b) viscosity of slag and metal, and (c) temperature, both of which affect the specific diffusion rate; and (d) the physical characteristics of the system, such as diameter of coke lumps, percentage of voids, etc.

#### Suggested Investigation

An investigation whose object would be to determine the constants necessary for the application of the fundamental equations to furnace operation should yield important information, both in regard to present practice and as a suggestion for future development. For example: the proper value for slag viscosity for a given size of metal drop could be predicted. If, from such a study, the correct viscosity could be predicted, it would then be possible to make such changes in the burden as to produce a slag which would possess the desired viscosity.

Again, as just suggested, it may be entirely advisable from a chemical standpoint to change the dimensions of the crucible so that with the same bosh and tuyere line the slag will occupy a greater depth and will consequently have greater opportunity for contact with the iron droplets. Fundamental data of the sort discussed herein would enable one to predict the extra amount of desulphurization to be derived from such a change. For example: if by adding 2 ft. to the depth of the slag layer, an additional 10 points of sulphur could be removed (as compared with 200 points in the present 3 ft. or so) it would be possible to use a considerably cheaper high-sulphur coke.

The same line of attack may be used in connection with the questions of manganese recovery and of silica reduction; it is probable that these two actions are more susceptible to the influence of temperature than to other factors. This question could readily be settled from a knowledge of the equilibria of the reactions involved and the absorption coefficients.

#### Acknowledgements

The data here presented were obtained and the theory worked out during the spring of 1926, while the writers were associated with the Massachusetts Institute of Technology. Owing to pressure of other duties, no opportunity has been offered for writing it up until the present. Thanks are due to the Director of the Bureau of Mines for permission to publish the results at this time.

Acknowledgement is also made of the assistance rendered by Professor William P. Ryan, then Director of the Buffalo Station, School of Chemical Engineering Practice, Massachusetts Institute of Technology, and Mr. J. B. Goldberg, then a student in the school. The writers are likewise indebted to the Bethlehem Steel Company, in whose Lackawanna plant a number of investigations were carried out.

#### Biography

<sup>1</sup>Kinney, S. P., Composition of Materials from Various Elevations in an Iron Blast Furnace. Tech. paper 397, Bureau of Mines, 1926, 22 pp.

<sup>2</sup>Goldberg, J. B., Unpublished thesis, Mass. Inst. Tech., 1926.

<sup>3</sup>Michel, A., Factors Affecting Total Carbon in Pig Iron. Stahl und Eisen, vol. 47, 1927, p. 696. Cf. Iron Age, vol. 120, 1927, p. 535.

<sup>4</sup>Gaines, J. M., Jr., Unpublished thesis, Mass. Inst. Tech., 1926.

<sup>5</sup>Kinney, S. P., see reference <sup>1</sup>.

<sup>6</sup>Sweetser, R. H., Carbon in Pig Iron. Tech. publication No. 11, Amer. Inst. Min. and Met. Eng., 1927.

<sup>7</sup>Wuest, F., On the Theory of the Blast Furnace Process. Jour. Iron and Steel Inst., 1927.

<sup>8</sup>Whitman, W. G., Two-Film Theory of Gas Absorption. Chem. and Met. Eng., vol. 29, 1923, p. 146.

<sup>9</sup>Feild, A. L., and Royster, P. H., Slag Viscosity Tables for Blast-Furnace Work. U. S. Bureau of Mines Tech. paper No. 187, 1918, 38 pp.

#### Timken to Increase Production

An announcement has recently been made by the officials of The Timken Roller Bearing Company that an expenditure of \$4,000,000 to be devoted to increasing the production facilities of the company has been authorized for the coming year. The greater part of this expansion program concerns the company's plant at Canton, where both the steel mill and the bearing manufacturing plant proper will be considerably enlarged. Among other features a new substation of greater kilowatt capacity will be built for supplying electric power for both the steel mill and the factory. Some idea of the magnitude of the expansion can be gained from the fact that the contracts for steel construction alone amount to \$300,000 or more.

This enlargement of the company's facilities has been rendered necessary by the increase in business which marked the end of the past year, and by the expectation of still greater increase in 1928. Several factors have contributed to this increase, among them being orders from various automotive manufacturers, and the growing demand for Timken steel. Business in the various industrial fields in which the bearings have become established, has decidedly been a determining factor.

# Promotions at Jones & Laughlin

**T. M. Girdler Becomes President of the Corporation Succeeding Charles A. Fisher—Other Officials Advanced—  
Policy of Organization to be Maintained**

THE recent changes in management of the Jones & Laughlin Steel Corporation, caused by the unexpected death of B. F. Jones, Jr., chairman of the board of directors, are looked upon by the steel industry in general as insuring the continuation of the company's policy of efficiency and progressiveness. The general comment in the steel trade and in the trade and financial papers connected with the industry is to the effect that these changes in management are a clear indication that Jones & Laughlin is not interested in any manner in the merger and consolidation projects now being widely considered, but intends to go ahead as before, the largest independent steel company in the United States, measured by growth.

The elevation to the presidency of T. M. Girdler, formerly general superintendent here and later general manager of all works and properties, is taken generally to mean that Jones & Laughlin will move forward into greater activity and development. Mr. Girdler's prompt action in appointing a group of younger men who have served under him for many years, to the highest operating positions in the corporation, has been well received by the steel industry.

The new president of the Jones & Laughlin Steel Corporation, T. M. Girdler, came with the organization in 1914 as assistant to the general superintendent of the Aliquippa works, Woodlawn, Pa. He was successively made assistant general superintendent and general superintendent of the Aliquippa works and general manager of all the plants and properties of the corporation. Mr. Girdler was elected vice president in charge of operations and a director in January, 1926. The following year he was made a member of the executive committee.

Mr. Girdler graduated from Lehigh University in the class of 1901, with the degree of mechanical engineer. He started his career in the steel business in 1902 with the Oliver Iron and Steel Company.

Upon taking over the presidency of Jones & Laughlin, Mr. Girdler at once advanced several young men in the operating division to high executive positions. None of the men advanced is more than 44 years old. Two of them are native Pittsburghers, and one of these rose from the ranks within the organization. The appointments are as follows:

R. J. Wysor has been made general manager of all works and properties of the corporation, succeeding Mr. Girdler in this post. Mr. Wysor was assistant general manager.

Frederick E. Fieger has been made assistant general manager of works and properties, succeeding Mr. Wysor. Mr. Fieger was general superintendent of the Jones & Laughlin Aliquippa works, Woodlawn, Pa.

J. Z. Collier has been made general superintendent of the Aliquippa works, Woodlawn, Pa., succeeding Mr. Fieger. Mr. Collier was general superintendent of the South Side works, Pittsburgh.

S. S. Marshall, Jr., has been made general superintendent of the South Side works, succeeding Mr. Collier. Mr. Marshall was assistant general superintendent of the South Side works.

H. D. Stark succeeds Marshall as assistant general superintendent of the South Side works.

R. J. Wysor was born in Dublin, Va., in 1885. He received his technical education at the Virginia Polytechnic Institute, graduating with the class of 1906. During the next four years he was chemist and assistant chief chemist at the Duquesne works of the Carnegie Steel Company. In 1910 he became metallurgist for the Panama Canal Commission, and subsequently held successively the following positions with the Bethlehem Steel Company: chief chemist and engineer of tests 1912-16, superintendent of blast furnaces 1916-18, superintendent of the service division, Bethlehem plant, assistant general manager, Maryland plant, Sparrows Point, 1919-23, and assistant general manager, Cambria plant, Johnstown, 1923-25. He came to Jones & Laughlin in 1925 as assistant general manager.

Frederick E. Fieger, born in Pittsburgh in 1883, after completing his education, started to work in 1901, at the age of 18, in the engineering department of the American Tin Plate Company, now a part of the American Sheet and Tinplate Company of the United States Steel Corporation. He left them in 1909 to become a consulting engineer, with offices in the House Building, Pittsburgh. In 1913 Fieger went with the Whitaker-Glessner Company, now a part of the Wheeling Steel Corporation, as chief engineer, becoming general manager of their Portsmouth (O.) works in 1915. In 1917 he came to Jones & Laughlin as superintendent of wire department at the Aliquippa works. In 1918 he became superintendent of steel works at Aliquippa; in 1920, assistant general superintendent, and in 1923, general superintendent of the same works.

J. Z. Collier, born in Atlanta, Ga., in 1887, is a graduate of the Georgia School of Technology, class of 1906. In 1907 he came to Pittsburgh and went to work for the Westinghouse Machine Company. His first position with Jones & Laughlin was in 1918 as assistant chief engineer of their Aliquippa works. Subsequently he became superintendent of the blooming mill and steel works superintendent at Aliquippa, and in February, 1923, was transferred to the South Side works as assistant general superintendent, becoming general superintendent of those works January 1, 1926.

Marshall's entire career has been with Jones & Laughlin. Born in Pittsburgh in 1886, when 17 years old, in 1903, he went to work in the engineering department of the Eliza furnaces of the Jones & Laughlin Steel Corporation. Later he became superintendent of construction for the works on the north side of the Monongahela river, and subsequently general master mechanic of the Soho department. In 1917 he was made assistant general superintendent of the North Side works, and in 1925 assistant general superintendent of the South Side works.

Stark entered the service of the Jones & Laughlin Steel Corporation in 1899, at the age of 17. He was first employed in the engineering department of the South Side plant, and in 1908 was advanced to the position of superintendent of machine shops in the same plant. In 1911 Mr. Stark was again promoted, when he was made superintendent of the steel works and blooming mills.

## Executives of Jones & Laughlin Steel Corporation



Top—R. J. Wysor  
Bottom—S. S. Marshall, Jr.

Top—T. M. Girdler  
Bottom—J. Z. Collier

Top—F. E. Fieger  
Bottom—H. D. Stark



# A Newly Constructed Seamless Tube Mill

A Description Bringing Out Important New Features in the Design of a Large Roll Type Piercing Mill—Entirely Motor Driven—Rapid and Accurate in Production

By CHARLES A. COLGATE\*

THE Standard Seamless Tube Company has recently installed at its Ambridge plant a new 51-in. roll type piercing mill with several innovations in the design from the conventional type piercing mill. The mill was designed and built by the Mesta Machine Company, with the Standard Seamless Tube Company collaborating in the design, and is the largest of its type so far built in this country, if not the largest in the world. It will produce a tube 15 in. O. D. x 31 ft. long max.

A 5000 hp. (12,500 hp. max. momentary), 240 rpm., 2200 v. dc. synchronous General Electric Company motor drives the mill through a single reduction gear unit consisting of two 88 in. P. D., 38-in. face,  $1\frac{1}{4}$  D. P. single helical gears with a 22-in. P. D. 38-in. face pinion giving a mill speed of approximately 60 rpm., corresponding to a roll surface speed of about 800 ft. per minute.

The gear drive unit stands approximately 17 ft. high from the base and is made of cast steel in three main sections parted at the bearing centers. The bearings are of ample proportion, cast steel shells lined with motor marine babbit with both forced feed and ring oiled lubrication.

The drive alone weighs more than 500,000 lbs., and is held on the foundation by four 6 in. foundation bolts. The bottom gear dips into oil and the top gear is oiled by

means of a motor-driven pump feeding oil on its face. Ample provision is made to prevent mixing of tooth and bearing lubricants. The 5000 hp. motor is connected to the gear unit by a Mesta universal coupling running in oil and entirely enclosed in a cast steel case. Both the gear shafts and roll shafts are bored for a grease passage to the universal joint on the spindles. The drive is connected to the mill by universal spindles, as is the case in good blooming mill practice; the spindles are approximately 20 ft. long with pressure grease lubrication on the slippers and are carried on a spindle carrier which also forms a portion of the inlet trough. The shifting of spindles is made easy and fast, for all that is necessary is to hook the mill crane onto the shift arm and hoist up.

The inlet trough will take a billet 17 ft. long. It is of cast steel with cast iron guide liners in two sections, each held by one lever clamp, which makes guide changing fast and convenient.

The pusher is air cylinder operated, with the carriage a one-piece steel casting running on a track of forged steel 8 x 12 in. in cross section. This track or arm is supported entirely on the gear drive unit and does not rest on the mill cap. This design facilitates roll changing. The pusher cylinder is also carried on the gear drive unit, passing entirely through the drive, being well protected. Over-travel of pusher carriage is arrested on both ends

\*Mechanical engineer.

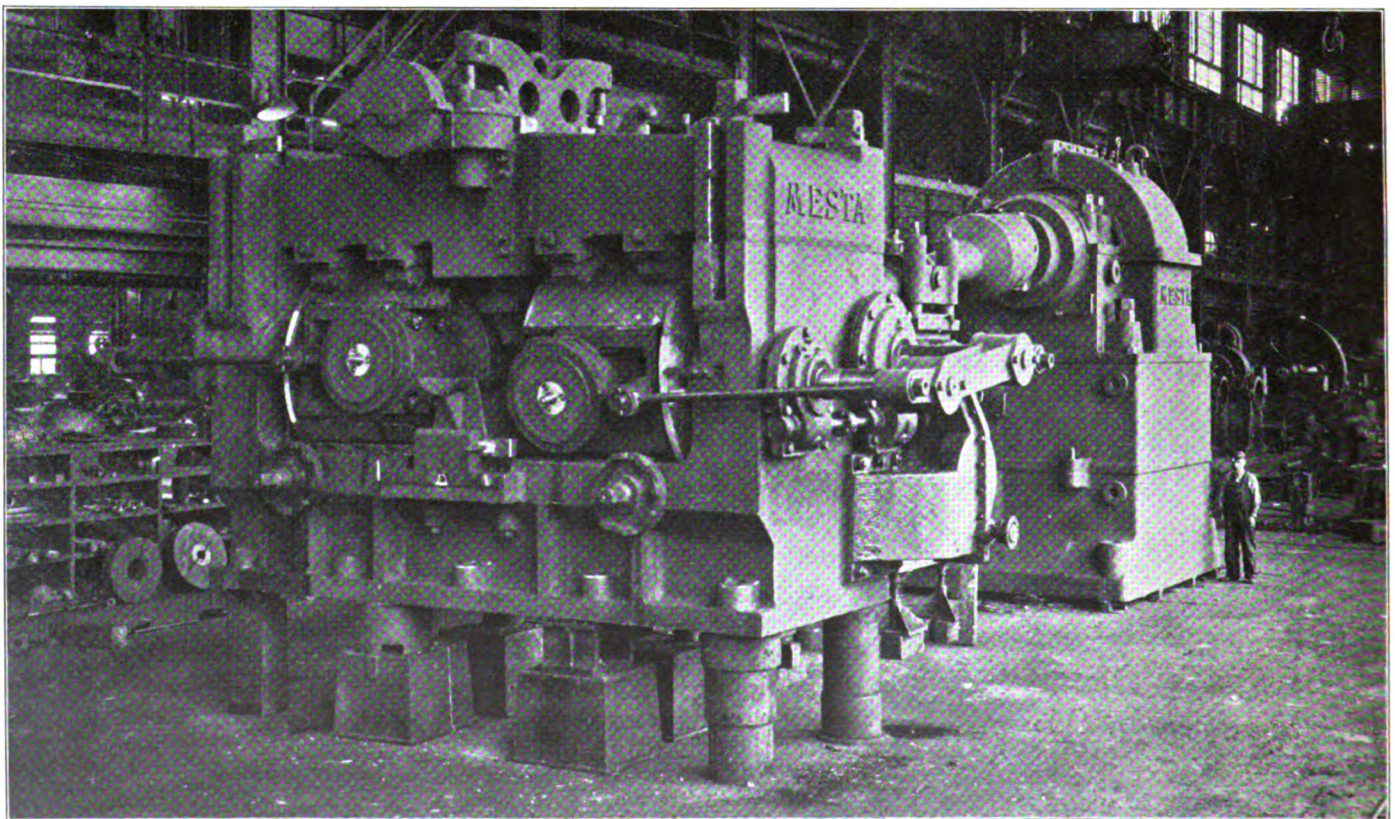


FIG. 1—Roll type piercing mill.



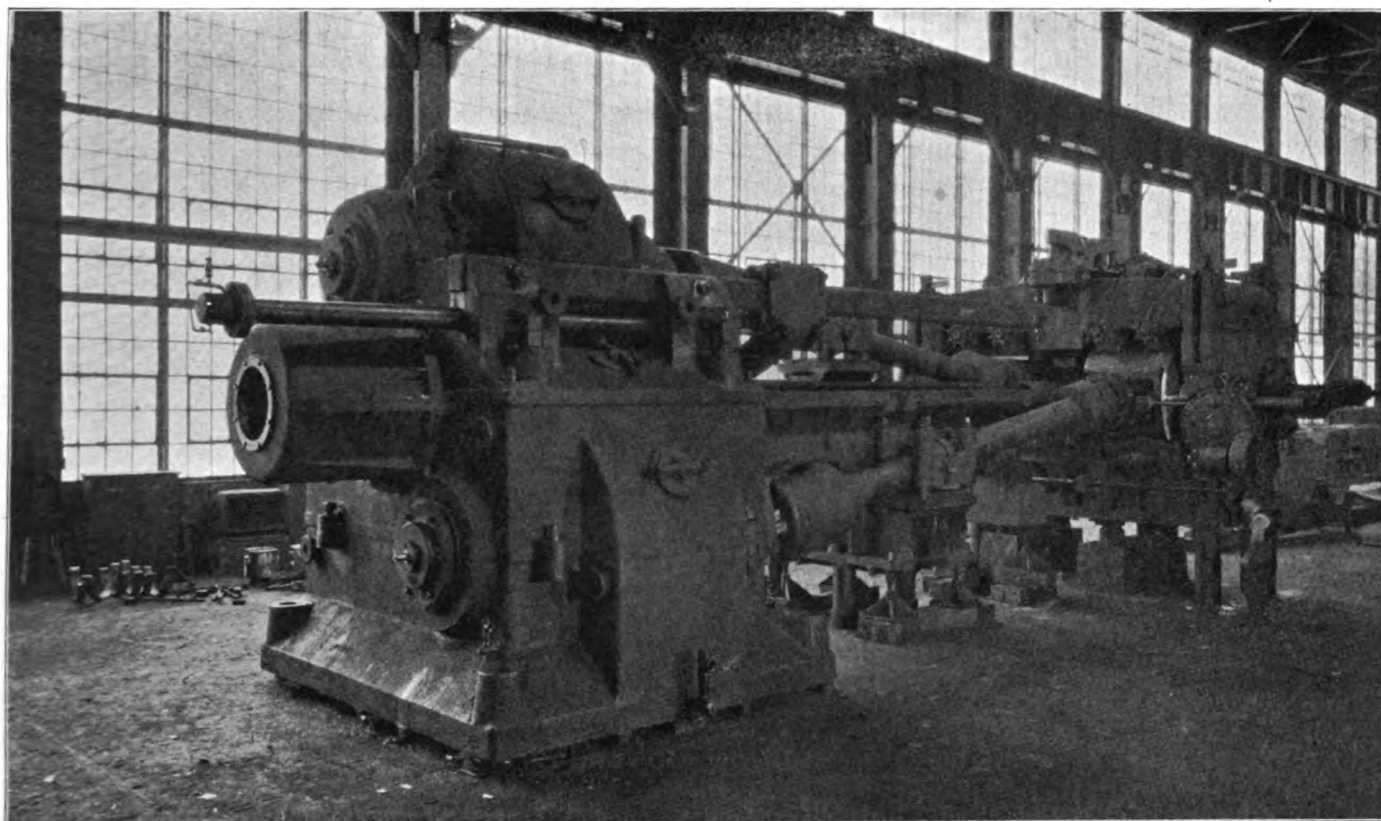


FIG. 2—Gear drive Unit.

by air cushion; all air cylinders are designed to operate on a minimum of 60 lbs. at the cylinders.

#### Mill Proper

The mills are of heavy massive cast steel construction, all castings where practical being of box section. The rolls are approximately 51 in. maximum diameter x 24-in. face with 20 x 22 in. necks running on motor marine babbitted bearings carried in heavy cast steel cradles. The cradles are rotated for angular adjustment of rolls by jack screws which are turned by hand with bars or by mill crane by means of a drum mounted on the screws, and the cradles are locked in position by wedges in housing and cap. Indicators are provided to show exact angular position of rolls. The horizontal roll adjustment is motor driven with one motor moving both rolls simultaneously, through worm gearing and forged steel screws driving through heavy bronze nuts with pressure lubrication. Roll pull back rods are entirely outside the housing and are spring balanced. The top guide holder is motor adjusted, while the bottom guide is adjusted by wedge and screw.

The design of the cap was influenced to a considerable extent by limitations of crane capacity and clearance. All fitting surface between cap and housing are lined with forged steel liners and four large swinging bolts with wedges and washers hold the cap to the housing. The outlet end has several innovations in design and entirely new features, being semi-automatic in adjustment for different tube sizes. The guides consist of only four interchangeable steel castings. The guide casting consists of three heavy fingers cast integral with an 18 in. sq. box section carrying a trunnion on either end turned to fit on three base castings which are machined to receive the guide trunnions. Each of the four guide castings carries an adjusting arm, actuated by jack screws, turning in bronze nuts in two adjusting boxes on either side of the

outlet. To change from one size tube to another it is only necessary to loosen the sledging nuts and give the screws a few turns and the guides are lined up. This system of guides gives very close guiding, does away with spring, vibration and the necessity of carrying a large stock of spare guides with the time and trouble of changing them.

Two motor-driven drag out rollers are provided, operated in the vertical plane by a link and lever motion connected to an air cylinder, with worm and segment adjustment for the different tube sizes. These rollers are each driven by a 5 hp. a.c. induction motor through single helical cut gears running in oil. The kick out is air operated and consists of six cast steel fingers mounted on a 7-in. diameter forged steel shaft 26 ft. long, carried on four babbitted bearings mounted on the adjusting and trunnion bases, making a very neat and substantial job.

The thrust block housing design was influenced by the fact it must be readily removable, as at this point a 14 in. shaft driving the plug mill had to be cleared and so arranged that this shaft could be taken out quickly in case of a breakdown. The thrust block housing consists of a bottom half, top half and a heavy adjusting arm on either side of housing. The two adjusting arms are carried on trunnions on the bottom half of housing, with their top ends bored and bushed to receive the latch and adjusting screw yoke. The latch with shaft and lever fits is of one-piece forged steel. On one adjusting arm is mounted the latch operating cylinder; on the other is mounted the latch pull back spring and rod. Both arms are bored to receive compression cushion springs for stopping the thrust block, the design being such as to bring the latch down tight on the latch block before the billet enters the rolls. For adjusting the thrust block bearing with relation to the mill it is only necessary to turn the nut on the adjusting screw which projects out from the top half of housing.

(Continued on page 248)

# The Dressing of Rolls by Grinding

Touching on the History of Grinding Rolls, the Advantages of This Method of Roll Dressing Are Fully and Clearly Outlined—Special Grinding Operation in Forming Rolls

By HAROLD J. PRATT\*

**A**BOUT 40 years ago the first machine for dressing rolls by grinding was invented and almost immediately its efficiency became apparent. It was demonstrated that time and labor could be saved by the then newer method and the life of the rolls was prolonged. But the very nature of the machine limited its field. It was rather light in construction and therefore could not be employed for dressing the huge rolls used in plate mills. Its scope was rather limited to small rolls and to polishing calendar rolls for paper-making machines.

Yet the efficiency of the operation was evident to plate mill operators. Rolls at that time and even now in some plants, were dressed on a lathe. This operation was comparatively slow and costly. In some instances as long as 24 hrs. were required to dress a roll and the process removed a considerable portion of the chilled surface of the roll. The degree of accuracy with which the cylinders could be turned was limited. Obviously the quality of the product was not as near perfect as the mills desired.

In 1913 the first large grinding machine for dressing plate mill rolls was completed by Norton Company and its first tests met with such success that this type of machine soon became part of the equipment of the larger and more modern plant. These machines removed the limit from the size of the rolls which could be ground. They also permitted convexing, concaving, tapering the roll body and grinding the journal or "neck" of the roll, previously an impossible operation.

Rolls used in plate, sheet and tin plate mills vary in size from the small type, 8 to 12 in. in diameter and 6 to 10 in. long, to those 15 to 60 in. in diameter and 168 to 180 in. long. The shape of the rolls vary. Some of the small and long rolls are tapered at the ends and crowned at the center. Others are concaved. Still others are perfectly straight cylinders depending largely on the nature of the work. They are mounted above one another in combinations of two, three or four rolls.

Obviously these rolls must be accurately machined to produce a uniform product. As they are used their surfaces become worn and irregular and they must be redressed frequently. The common practice is to change them twice weekly and to true them to form after each removal. In this manner the mills are certain that their products will have a uniform thickness and texture and the standard of quality maintained.

## Comparison of Methods

The two methods of dressing rolls are by grinding and by turning in a lathe. With the lathe, in order to penetrate beneath the worn face of the roll, considerably more material is removed than in the grinding operation. The moment the grinding machine has cleaned up the last imperfections in the face, the operation is completed. With the lathe, because of the coarseness of the operation, quite heavy chips are usually taken, and after the blemishes have been re-

moved there still remains the necessity of trueing the surface. If a hard spot is struck, the lathe tool tears out the metal and the operation must be continued until the depth of the torn part has been reached.

In dressing rolls every thousandth part of an inch saved on the diameter increases the life of the roll to a degree well worth taking into consideration. The chilled surface of the most commonly used type of roll is from 1/2-in. to 5/8-in. deep. The life of the roll is the length of service before this chill is worn away, so that every small fraction of an inch retained on the diameter results in a material money saving. It is estimated that a roll dressed by grinding has 50 per cent longer life than one dressed by turning.

The grinding process also leaves the necks or journals of the rolls concentric with each other within very small limits which results in a material saving in the babbit used for journal bearings because of the trueness and smoothness of the journal and the consequent smaller wear on the bearings. The grinding machine also reduces the dressing time about 75 per cent and produces a much finer finish. Following is an interesting report of a large steel mill which has used a grinding machine for 15 years in dressing plate mill rolls.

"A 54 x 252" Norton roll grinder machine was installed in the Roll Department the latter part of 1915 and has run almost continuously, double turn, since that time, with a minimum loss of time due to repairs and so forth. The average production per month for a number of years has been 120 rolls, both new and dressing. The maximum has been as high as 142 rolls. We feel that the roll grinder replaces three to four roll lathes, working double turn.

Grinding plate mill rolls have largely eliminated the difficulties caused by spalling. It also gives the mill rolls that are uniform as to surface, diameters and tapers which is humanly impossible when done in a roll lathe. This makes for easier lining in the mill as well as a greater life before development of irregularities in surface, and is, no doubt, reflected in the increased tonnage as shown below.

One of the greatest savings made possible by grinding is the case of dressing plate mill rolls which have burned in the mill. When done in a lathe, since a burned spot is too hard to cut, it is necessary to dig under it, thereby removing a comparatively large amount of stock. When grinding, this loss is eliminated as there is no difference noticeable to the grinder between the burned and unburned portions of the roll. This fact is indicated below by the increased number of dressings obtained per roll. The grinding wheel cost per roll ground is about \$1.25; dressing tool cost is about 18 cents.

In the analysis below, the figures are based on the average of the five rolls which had given the best tonnage previous to the installation of the roll grinding machine, as compared with the average of the five rolls having given the greatest tonnage since the installation of the grinder. It is self-explanatory.

\*Norton Company.

TABLE I

| Mill        | Roll size | Tonnage with turned rolls | Tonnage with ground rolls | % inc. in ton due to grind. | No. dress. using lathe | No. dress. using grind. mach. | Tons per dress. using turned rolls | Tons per dress. using ground rolls | % in. tons per dress. due to grind. |
|-------------|-----------|---------------------------|---------------------------|-----------------------------|------------------------|-------------------------------|------------------------------------|------------------------------------|-------------------------------------|
| 140" Middle | 22 x 141" | 26,156                    | 41,120                    | 57.2                        | 13                     | 17                            | 2,012                              | 2,419                              | 20.2                                |
| 128" Middle | 21 x 128" | 28,567                    | 32,723                    | 14.5                        | 15                     | 17                            | 1,904                              | 1,904                              | 0.0                                 |
| 84" Middle  | 20 x 88"  | 10,500                    | 16,406                    | 56.0                        | 18                     | 22                            | 583                                | 746                                | 21.8                                |
| 72" Middle  | 18½ x 75" | 9,160                     | 14,589                    | 59.0                        | 20                     | 26                            | 458                                | 561                                | 18.4                                |

TABLE II

| Mill        | Ave. dress. turned rolls | Ave. dress. ground rolls | % reduction amt. of dress. due to grind. | Ave. total red. using lathe | Ave. total red. using grind. mach. | Ave. dress. time on lathe, hrs. | Ave. dress. time on grind. mach. | Min. dress. time on grind. mach. |
|-------------|--------------------------|--------------------------|------------------------------------------|-----------------------------|------------------------------------|---------------------------------|----------------------------------|----------------------------------|
| 140" Middle | 0.090"                   | 0.064"                   | 29.0                                     | 1 7/64"                     | 1 3/64"                            | 12 4½                           | 2½                               | 2½                               |
| 128" Middle | 0.085"                   | 0.080"                   | 29.0                                     | 1 ¼"                        | 1 5/16"                            | 12 4                            | 2½                               | 2½                               |
| 84" Middle  | 0.060"                   | 0.052"                   | 13.0                                     | 1 3/64"                     | 1 9/64"                            | 7 3                             | 1½                               | 1½                               |
| 72" Middle  | 0.055"                   | 0.047"                   | 15.0                                     | 1 3/32"                     | 1 3/16"                            | 5 2                             | 1                                | 1                                |

TABLE III

| Mill                | Roll size  | Minimum dressing time on grind. mach. | Average dressing time on grind. mach. | Average dressing time on lathe |
|---------------------|------------|---------------------------------------|---------------------------------------|--------------------------------|
| 140" Top and bottom | 38½ x 140" | 5 hrs.                                | 6½ hrs.                               | 15 hrs.                        |
| 128" Top and bottom | 35 x 128"  | 4½ hrs.                               | 6 hrs.                                | 15 hrs.                        |
| 110" Top and bottom | 36 x 110"  | 3½ hrs.                               | 5 hrs.                                | 12 hrs.                        |
| 84" Top and bottom  | 32½ x 86"  | 2½ hrs.                               | 4 hrs.                                | 10 hrs.                        |
| 72" Top and bottom  | 30 x 74"   | 2 hrs.                                | 3 hrs.                                | 8 hrs.                         |

Two methods are commonly employed in grinding rolls. In one the roll is supported on the centers of the headstock and footstock of the machine. In the other the roll is ground while rotating on its own journals in specially designed supporting blocks, commonly known as pillow blocks, "journal rests" or neck bearings. The first method is sometimes employed on light rolls which are easily supported on centers. Rolls as large as 30-in. diameter and 120-in. length of face have been successfully ground by this method. The better method is to support them in neck bearings, in the same manner in which they operate in the mill.

In grinding the face of a roll while it is revolved on its own necks or journals the degree of perfection attained is dependent largely on the accuracy of the center holes used to support the roll when the necks or journals were finished. The common cause of error lies in imperfections of the lathe spindles on which the necks are turned or eccentricity of the center points in the rotating lathe spindle. A careful test with a good indicator reading to thousandths of an inch would probably show that nearly every roll turning lathe has a spindle bearing out of round and a center point out of true; and also that the center holes in the rolls seldom are true. Mechanics who grind accurate work in tool making and machine building,

grind on two dead centers, which is the best method for obtaining precision.

If the necks are perfectly cylindrical over their entire length, and if they are in perfect line with each other, then, and then only, will the grinding of the roll when rotating on the necks give accurate results. This condition can be guaranteed only when the necks themselves have been ground on dead centers and with centers and with center holes filling the centers perfectly.

To grind successfully on centers the centers must be large and strong and made of good material. The bearing portion of the center holes in the ends of the rolls must be perfectly conical, true and large enough to prevent shearing.

The most successful practice is to use center holes having a 60-deg. angle in the work, with the mouth of the angle large enough for a center of the strength necessary to support the heaviest work. Not uncommonly the roll maker uses a special center having a 90-deg. angle, or some other angle larger than 60 deg., as a preventative measure against breakage of the center point. Center holes should have a drilled clearance hole for the point of the center, and should be guarded very carefully against damage while rolls are mounted in the mills.

In truing the roll necks, which is always done to keep them cylindrical and concentric with the roll face, two methods are used. The more common is to support the roll on centers, although specially designed neck bearings have been made, which make it possible to grind while the rolls are rotating on their own bearings. The nature of the neck grinding operation requires that the corner of the wheel be trued to a radius in order to grind the fillet which takes the thrust of the roll when it is operating in the mill. These fillets range from ⅜ in. to 3½ in. in radius.

### Roll Grinding Machines

Rolls of small diameter and light weight are ground most commonly in the ordinary type of cylindrical grinding machine, the method being no different from that employed in other cylindrical work. The illustrations show such a machine arranged for roll grinding and also a special Norton machine designed for handling the larger rolls. A notable difference between the two is that in the regular cylindrical grinding machine the work is supported on a moving table which travels in front of a fixed wheel, whereas in the larger type, the work is fixed on the work base and the wheel travels back and forth over the ground surface. This method is more convenient for handling rolls of many tons weight. When the work table becomes so heavy that it is not economical to move it, the work should be fixed and the lighter member, which is the wheel head, reciprocated. The operator stands on the carriage beside the grinding wheel where he can control the operation of the machine easily, and at the same time see the point where the wheel comes in contact with the work.

Rolls are usually rotated from 100 to 200 s.f.p.m. and the grinding wheel at from 4500 to 6000 s.f.p.m. The table traverse or wheel traverse, as the case may be is regulated so that the distance of travel for each revolution of the work is slightly less than the width of the wheel, in order to obtain the most economical production.

### Formed Rolls

The forming of rolls is done either by special attachments on the grinding machine, or by certain



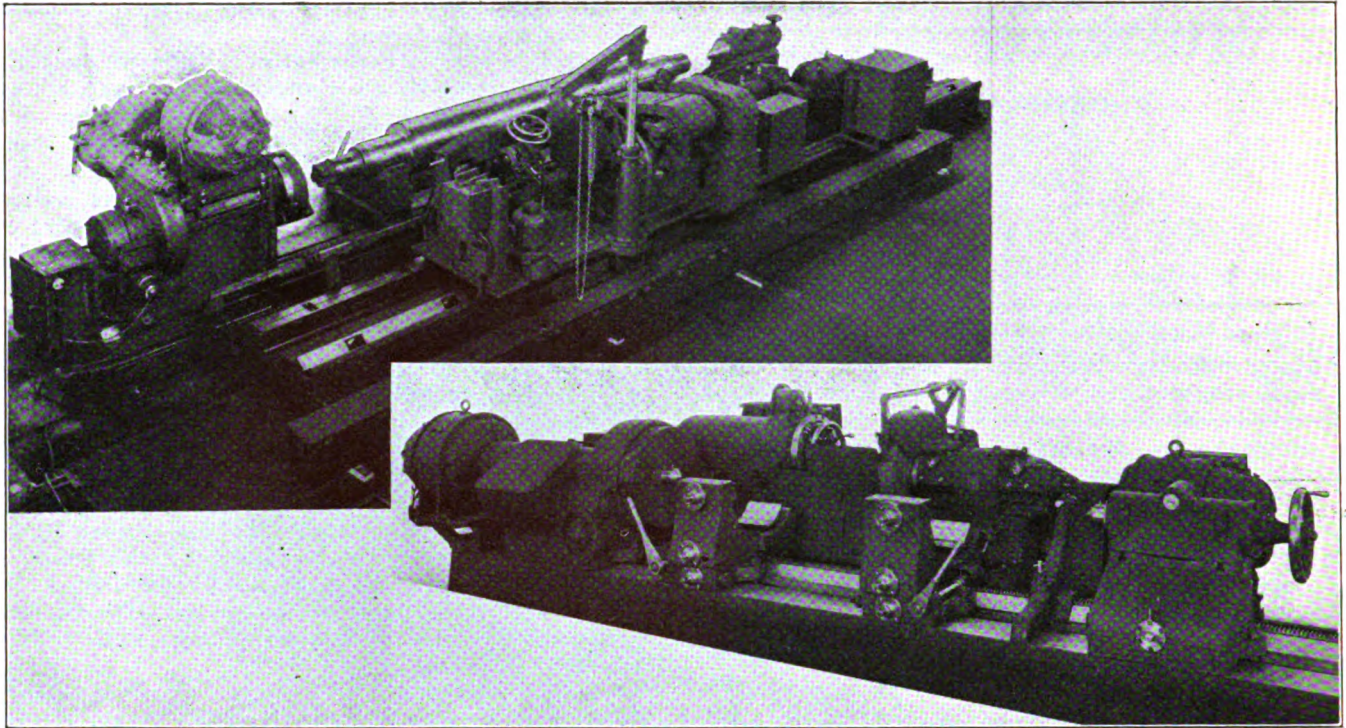


FIG. 1, (Upper)—View of the 54-in. x 21-ft. 0-in. roll grinding machine showing the general arrangement.

FIG. 2, (Lower)—Norton 36-in. roll grinding machine—Front view of machine.

changes in the machine construction. Either a concave or convex face may be given the roll, and it may be tapered from both ends, or it may be ground straight.

Some work, especially strip or ribbon stock, requires that the face of the roll be crowned slightly. There are several methods of producing a crown on the small rolls, one by forming the desired shape in the face of the wheel and feeding it straight in against the roll face. This can be used only when the grinding wheel can be wider than the roll face. Another is by means of an attachment on the machine for controlling the movement of the wheel slide, where the wheel is mounted on the traversing member of the machine. On smaller machines where the roll is carried on a traversing table, means are provided for swiveling the table slightly as it passes the grinding wheel thus providing a varying diameter on the roll.

Tapers or irregular forms are small in amount as compared with the diameter of the roll. For example, on small rolls for ribbon stock the crown may be from 0.001 in. to 0.015 in. high. On large rolls 36 in. in diameter and 90 in. long, the taper or curve may amount to 1/16 in. in the length of the face.

Long and comparatively slender rolls for tinning mills require a slightly crowned face. This compensates for the deflection in the rolls caused by the pressure on the work which comes between the journals on which the rolls are supported. In addition to the generation of a suitable crown the requirements for accuracy and finish are very exacting. These qualities are necessary to give even distribution of molten tin on the steel sheet. Even distribution of the tin is also most economical and the resultant finish on the tinned sheet is the best. These rolls are used in a machine similar to a clothes ring which removes the excess tin from the steel sheet.

To accomplish the generation of the crown in a simple grinding operation, an attachment known as

a "pull back rest" is employed on a standard 14-in. cylindrical grinding machine. This fixture is located on the work table at the center of the roll and by the arrangement of curved steadyrest jaws and a tension screw and nut, a clamp and a weighted lever, the roll is bowed from the wheel. The amount of the crown produced by grinding the rolls in its deflected shape is regulated by the variation in the tension applied through the screw and nut.

Steadyrests support the roll on the journal bearings close to the body so that the deflection will be uniformly distributed in the roll body. Additional steadyrests may be used on the body of long rolls to help govern the form of the crown or add to the steadiness during the grinding operation.

A dial indicator is instrumental in setting up the work to obtain the proper crown. The roll is first ground to clean at the center in the ordinary manner, the indicator is then brought against the roll and dial reading noted. The wood faced jaws of the pull back rest are set in position and tension applied through the pull screw and nut on the front of the attachment until the indicator shows the desired deflection has been obtained. The indicator is swung from contact with the roll and the grinding operations carried on from this point in the same manner as on a straight bar.

Where this statement has been used on tinning mill rolls, very satisfactory results have been obtained both as to the accuracy of the form and the quality of finish. Other methods used to grind crowned tinning mill rolls usually require a special set-up for each form ground. The time consumed in this operation is saved where the pull back rest method is employed. A further advantage favoring the use of this attachment for crowning slender rolls lies in the fact that the machines for this work do not need to be special which makes them adaptable for ordinary cylindrical grinding without any change in their arrangement.



# Sheet Steel for Automobile Bodies

## A Detailed Non-Technical Discussion of the Importance of and the Processes Involved in the Manufacture of Automobile Body Sheet Steels "AUTOSHEET"

**T**HROUGHOUT this industrious country there is one outstanding enterprise which directly and indirectly influences more people than any other that can be named at the present time. That industry is none other than the manufacture of automobiles.

Whether or not we are engaged in the manufacture or selling of automobiles or its accessories, we—the average American citizen—are certainly interested, for the sake of our pocketbooks, in the purchasing of a quality car at a minimum cost. Within the last few years we have witnessed keen competition among the automobile manufacturers with its attendant slashing of prices, improved performance and service and the falling by the wayside of those companies too small to maintain either service or quality. Consolidation of the smaller companies has, therefore, been necessary to combat mass production of the larger companies. Not only has mass production and mergers brought about a lower priced car, but with the increasing demand for neater appearing bodies, it has placed a heavy load of responsibility upon sheet steel mills to produce sheets having ductility and strength to make these intricate and difficult body stampings.

It is interesting to review the rapid strides that have been made in automobile body manufacture. Ten years ago a closed-in body was unheard of. The average car was for only those willing to pay the price, and pay they certainly did! The body was built in straight sections of steel and wood with right-angle bends to make up the necessary corners. The sheet steel used would be waste material today, as it was so full of pits, open surface and other surface imperfections that it was often necessary to putty over some of the pits before paint could be applied! The word painting fails to describe that process. As high as 16 finishes, including the prime coats, was not uncommon practice, and between these coats of paint hand polishing and sanding, followed by lacquering, constituted the usual procedure. The result was a fine finish, with the resulting price of the car out of the average man's reach.

A change in the model or the shape of the body was a factor seldom altered. The money and time now spent in the revising of models was used at that time in assembling and painting. What a contrast to our present methods! Models changed once and sometimes twice a year! The closed car, representing the majority of styles made, has a surface finish which surpasses by far the 16-coat job of the old days, by simply spraying on two or more coats of paint or special "Duco" finish. The sheet steel used today not only has a surface practically free from surface defects, but must be of such a softness that it will make intricate stampings which, when assembled, produce a car with body lines that appeal to the eye. And, best of all, produced at a price within the reach of most of us.

At this time we have approximately 22,000,000 pleasure cars in operation in the United States, surpassing by four or five million the number of telephones used in the same area. It is predicted by those in authority that between 4,000,000 to 5,000,000 pleasure cars will be produced and sold during the year of 1928, and this figure is probably a conservative estimate, as the new Model A

Ford and the new Chevrolet are getting into production. The advent of mass production on cars such as these will hit the average pocketbook, for the public awaits a moderately priced car giving satisfactory performance and service.

All of this reflects directly on the steel industry for, as mentioned before, the majority of cars are closed models of all steel construction. Outside of the structural shapes and rod which make up the chassis and the motor, axles and wheels, the remaining steel is in the form of sheets. The sheet steel manufacturers rank third among the products of the steel group, and sheets for the automobile trade are the backbone of the sheet steel industry. There are approximately 30 sheet steel manufacturing companies in the United States who produce a total yearly tonnage slightly over 5,000,000 tons. Out of this annual production of 5,000,000 tons the auto manufacturers consume 40 per cent of it, while the jobbers are the next in line with only 14 per cent consumption. From here the percentage used in the manufacture of electrical sheets, metal furniture, etc., rapidly drops.

### Co-operation of Maker and User of Sheets

With the advent of a heavy production of automobiles, together with the fact that automobile body sheets are the backbone of the sheet steel industry, we can readily conceive that close co-operation must necessarily be had between these two industries for their mutual benefit. This relationship becomes more apparent each year as the auto body manufacturer relies more and more upon the sheet steel plant, while in turn the metallurgical departments of the sheet steel mills have expanded as their field of endeavor and activity broadens. It is a healthy situation. The expansion of both industries is directly proportional to their relationship and co-operation in solving their problems. Good stampings with low breakage plus mass production equals a quality car at a low price with good demand.

The auto body manufacturer rarely is in a position to outline a mill process for a sheet which must make a certain stamping. He, being the purchaser, can demand a sheet of good surface, strength and softness, at a reasonable price, thus leaving the bulk of the problems to the metallurgist. The metallurgist must study the stamping to be made, the punches and dies involved; from which he recommends a standardized or regularly processed sheet from his mill or makes up a special process to fit the requirements.

This all sounds and reads very well, but it often happens that the purchaser occasionally takes a wild fling by specifying the processing of his sheets, with the result that he shows his ignorance of its manufacture to a marked degree. On the other hand, the metallurgist may know the sheet game, but his knowledge of dies and punches may be limited to such an extent that, if the pressman so wished, the best sheet for the part could be broken or wrinkled by slightly varying the corner pressures on the die or the speed of drawing. Even though the metallurgist understands the situation, he is often powerless to

bluntly inform the press foreman or the die makers that their dies are wrong and that the steel is right. Diplomacy, personality, knowledge of men and how to handle them are prerequisites that go along with a metallurgist's knowledge of his sheet steel, and its processing.

The models, and therefore their component body parts, such as rear quarter sides, cowls, backs, doors, windows and fenders are changed so often to meet the demands of competition and public opinion that no part is really standardized, and it can all be summarized to the effect that all orders for body stock are individual in their physical properties and surface finish. It must be understood that a certain grade or type of steel is suitable for many body parts of a car, but the requirements for surface finish may vary. In spite of all this the majority of the sheet steel manufacturers have standardized a series of processing that will take in the majority of requirements for body stock. By varying the cold rolling before or after the anneal, or giving it a single or full pickle, certain special surface requirements can be met without materially affecting the physical, chemical or microscopical properties of the sheet.

With these facts in mind, the writer has outlined, in the following series of articles, the processing of automobile body sheet steel from the open hearth to finished stamping. These articles will take into consideration the open hearths used in making a refined steel for sheets, the bar mills, hot mills with their breakdown and finishing rolls, picklers, shears, annealing, normalizing, cold rolling and inspection. All of the above discussions are written in such a way that they can, at any point, be correlated with their effect on the stamping and appearance of the finished sheet. Thus it will be the writer's honest effort to better acquaint the automobile industry with the processing of sheets and show, at the same time, the difficulties which arise in processing which the consumer knows little or nothing about.

The processing, as well as the data contained therein, will deal only with 16, 18, 19, 20 and 22 gauge material which represent practically the only gauges used in the manufacture of automobile body sheets. While the various processes will be explained more or less in detail it will not be discussed to such an extent that at any time will we lose sight of its relation to the finished sheet and its use.

A short chapter on the general metallurgical characteristics present in low carbon steels for sheet manufacture will also be outlined and we will try and present it in such a manner as to make it as near a non-technical discussion as possible without destroying the idea for which it is included.

### Importance of Making Own Bar Stock

The art of making ductile sheet steel for difficult body stampings has many noteworthy accomplishments to its credit but the field of usefulness of sheet steel has just been entered and much has yet to be learned. The correct annealing for a resulting ductile sheet is lost if at the very start we have a steel which is "dirty" with non-metallic inclusions and saturated with impurities. Too much emphasis cannot be laid on the purifying of steel in the open hearth for the subsequent manufacture of sheet steel. Those companies who manufacture their own sheet bar are ahead of the game because they can control their product at the very start. While we are not committing ourselves to the effect that those manufacturers who must purchase their bars from the outside, are losers, common

sense will tell us that to a certain extent they work in the dark unless careful and periodical microscopical and chemical checks are made on purchased bar. As this article progresses this point will make itself more pronounced.

The refinement of ore in the form of pig iron and steel scrap for the ultimate use in sheet form is brought about in basic open hearth furnaces. These furnaces are shallow pans lined with magnesite or dolomite onto which the charge is laid. This charge in turn is melted down, tapped into a ladle, teemed from a ladle into molds, the molds stripped and the resulting ingot goes on to the bar mill after being reheated in ingot furnaces. These open hearth furnaces range in size with a capacity of 30-100 tons per charge or "heat." While opinions differ as to the best size of open hearth for the refining of sheet steel, it can be generally stated that within reasonable limits, the smaller the furnace the closer the control and the better the resulting product.

### The Open-Hearth Charge

The charge consists of pig iron, limestone and miscellaneous steel scrap such as sheet scrap from the shears and warehouse, croppings from the bar mill, ingot butts or partially completed ingots, broken sheet rolls and the accumulation of scrap from the pit or casting side of the furnace. It is well to mention here that most sheet mills who make their own sheet bar take great care in eliminating alloy scrap or rolls from the charge as the presence of small amounts of nickel, chrome, vanadium, or molybdenum, greatly influence the resulting physical properties of the sheet. Sheets containing these elements show a decreased ductility and the hardness is materially increased.

Table I shows the usual charge for a 50-ton furnace which is self-explanatory. The usual procedure is to charge the limestone first followed by the pig iron and then the miscellaneous scrap. This completes the charge which, including the time necessary to patch the walls and the bottom from the previous run, takes from one to three hours depending on the size of the furnace.

Following the charge, heat in the form of a long flame impinges down upon the charge through parts located at each end of the furnace. The flame comes through only one port at a time, its waste heat going out through the opposite port and into a brick chamber which retains part of the heat. About every 15-20 minutes the flame is reversed and the gases come through the opposite chamber which preheats the gas and air and reheating the opposite chamber thus raising the efficiency of the furnace. This gas and a sufficient amount of air ignite at the port, the resulting flame striking onto the charge. This heat is procured by powdered coal, fuel oil, tar, coke oven, natural or producer gas. These fuels have their advantages and disadvantages depending on their heat producing properties and local operating conditions, none of which are necessary to discuss here.

The resulting heat, periodically reversed from one end of the hearth to the other, melts first the light sheet scrap and then the pig iron. During this melt the molten iron trickles down through the charge and is being oxidized and purified. The impurities present such as phosphorous, sulphur, manganese, silica and some carbon pass off as a gas or combine with the slag. This melt is all within a period of four to eight hours and is known as the ore boil.



TABLE I

| Heats on Roof—14<br>Heats, Week—4<br>Tonnage, Week—<br>Recorder—S |         | Heats on Ports—14<br>Heats, Month—20<br>Tonnage, Month—<br>1st Helper—M |              | Heats on Checkers—274<br>Furnace Melter—CL<br>Heat Number—1482<br>Melter—K |         |             |             |
|-------------------------------------------------------------------|---------|-------------------------------------------------------------------------|--------------|----------------------------------------------------------------------------|---------|-------------|-------------|
| METALS CHARGED                                                    |         | Weight                                                                  | REFRACTORIES |                                                                            | Weight  | TIME RECORD |             |
| Pig Iron Cold .....                                               | 45,820  | Limestone .....                                                         | 8,300        | Last Heat Tapped—                                                          |         |             |             |
| Moulds and Stools .....                                           | 1,200   | Fire Clay .....                                                         | .....        | Time Patching—30 M.                                                        |         |             |             |
| O. H. Pit Scrap .....                                             | .....   | Scale .....                                                             | .....        | Began Charging—                                                            |         |             |             |
| O. H. Ingot Butts .....                                           | 1,890   | Graphite .....                                                          | 40           | Finished—                                                                  |         |             |             |
| Bar Mill Crops .....                                              | 4,560   | Raw Dolomite .....                                                      | 1,800        | Melted—                                                                    |         |             |             |
| Bar Mill Billets .....                                            | .....   | Calcined Dolomite .....                                                 | 1,750        | Tapped—                                                                    |         |             |             |
| Shear Scrap .....                                                 | 51,050  | Magnesite .....                                                         | .....        | Time of Heat—                                                              |         |             | H. M.       |
| Warehouse Scrap .....                                             | 5,070   | Total Refractories .....                                                | 11 890       | Time of Charging—                                                          |         |             | H. 3 M.     |
| Hot Mill Rolls .....                                              | .....   |                                                                         |              | Time of Melting—                                                           |         |             | H. 9 M.     |
| Annealing Boxes .....                                             | .....   |                                                                         |              | Time Between Heats—                                                        |         |             | H. 10 M. 50 |
| Annealing Bottoms .....                                           | 1,740   |                                                                         |              | Delays—                                                                    |         |             | H. M.       |
| Roll Turnings .....                                               | .....   | Number                                                                  |              |                                                                            |         |             |             |
| Sheet and Tin (bundled) .....                                     | 4,720   | Stopper Sleeves .....                                                   | 13           |                                                                            |         |             |             |
| Punchings .....                                                   | .....   | Stopper Heads .....                                                     | 1            | FUEL RECORD                                                                |         |             |             |
| Stirring Rods .....                                               | 180     | Nozzles .....                                                           | 1 1/4"       |                                                                            |         |             |             |
| Cast Scrap .....                                                  | 360     | Stirring Rods .....                                                     | 1            | Gas—                                                                       |         | cu. ft.     |             |
| Misc. Steel Scrap .....                                           | .....   |                                                                         |              | Cu. ft. per Ton—                                                           |         |             |             |
| Total Iron and Steel .....                                        | 116,590 |                                                                         |              | Oil—                                                                       |         | gals.       |             |
|                                                                   |         |                                                                         |              | Gals. per Ton—                                                             |         |             |             |
| ADDITIONS IN FURNACE                                              |         | Ingots                                                                  | Size         | Weight                                                                     | To Bank |             | To Pit      |
| Ferro Manganese .....                                             | 1,200   | 20                                                                      | 18 x 20      | 109,400                                                                    |         |             | 20          |
| Ferro Silicon, 10% .....                                          | .....   | CONDITION OF HEAT                                                       |              |                                                                            |         |             |             |
| Ferro Silicon, 15% .....                                          | 580     | Condition of Melt—Soft                                                  |              |                                                                            |         |             |             |
| Ferro Silicon, 50% .....                                          | .....   | Condition of Slag—Heavy                                                 |              |                                                                            |         |             |             |
| Ferro Phosphorus .....                                            | .....   | Kind of Tap—Good                                                        |              |                                                                            |         |             |             |
| Sulphur .....                                                     | .....   | Ladle Condition after Pouring—Spotty                                    |              |                                                                            |         |             |             |
| Titanium .....                                                    | 130     | Action in Mould—                                                        |              |                                                                            |         |             |             |
| Spiegel .....                                                     | 410     | Rate of Rimming—Fast                                                    |              |                                                                            |         |             |             |
| Copper .....                                                      | .....   | Condition of Moulds—Warm                                                |              |                                                                            |         |             |             |
| Iron Ore .....                                                    | 1,300   | Rate of Pouring—                                                        |              |                                                                            |         |             |             |
| Total Alloys .....                                                | .....   | Temperature—OK.                                                         |              |                                                                            |         |             |             |
| Additions in Ladle .....                                          | .....   | CHEMICAL ANALYSIS                                                       |              |                                                                            |         |             |             |
| Ferro Manganese .....                                             | .....   | Lab. Prelim.                                                            | Carbon       | Mang.                                                                      | Phos.   | Sul.        | Sil.        |
| Ferro Silicon .....                                               | .....   | Lab. Prelim.                                                            | .17          |                                                                            |         |             |             |
| Aluminum .....                                                    | 10      | Lab. Final                                                              | .10          | 0.42                                                                       |         |             |             |
| Total Metal .....                                                 | 120,220 | Specified                                                               | .07-.09      | 0.30-0.35                                                                  |         |             |             |
|                                                                   |         | Per cent                                                                | Weight       | REMARKS—                                                                   |         |             |             |
| Ingot Production .....                                            | .....   | 91.0                                                                    | 109,400      |                                                                            |         |             |             |
| Pit Scrap .....                                                   | .....   | .6                                                                      | 721          |                                                                            |         |             |             |
| Ladle Skull .....                                                 | .....   | 1.1                                                                     | 1,322        |                                                                            |         |             |             |
| Oxidation .....                                                   | .....   | 6.3                                                                     | 7,574        |                                                                            |         |             |             |
| Ingot Butts .....                                                 | .....   | 1.0                                                                     | 1,203        |                                                                            |         |             |             |
|                                                                   |         | 100.0                                                                   | 120,220      |                                                                            |         |             |             |

During the latter part of this ore boil the temperature of the bath has been raised to a point where carbon begins to deoxidize and bubbles up through the molten iron as carbon dioxide gas. This action generally marks the beginning of the lime boil which has been lying dormant at the bottom of the charge. The lime starts to rise to the top and in so doing violently agitates the charge absorbing the remaining impurities as named above, with the exception of carbon, and finally becomes part of the slag.

#### The Working Period

At this point we have eliminated practically all impurities except the carbon. Steel for sheets usually has a full carbon range of 0.05-0.15 per cent which is exceptionally low and is known as the dead soft or low carbon steel requiring more attention than steels

of a higher carbon range. Low carbon steels have a higher melting point and must be tapped at a temperature around 1500-1600 deg. C. (2732-2912 deg. F.). To do this, care must be taken to prevent oxidization of the bath which is known as burnt steel and presents an almost impossible heat for the manufacture of sheets due to its brittleness.

Therefore at the end of the lime boil we take a preliminary chemical test to determine the amount of carbon present and then start working the heat. This primarily means the presence of a soaking flame keeping the iron from oxidizing and raising the slag as well as the iron to a tapping temperature. To prevent oxidizing, additional pig iron is added which incidentally slightly raises the temperature of the bath.

The temperature of the charge is determined by working a long steel bar or stirring rod through the

bath. If it is too cold the end of the rod is pointed, if too hot it shows nicks on the bar near the end and if about right a clean square melting. Another method of determining temperature is to take a test spoonful quickly from the bath and slowly pour onto the floor. Its fluidity or rate of flow and the thickness or skull left on the spoon is a relatively good check on the temperature of the bath. Either one and usually both methods are used in the refining of sheet steel. Up to this point eight to 12 hours have been consumed in the charging, ore and lime boil and the working period.

Having reached the desired temperature another quick chemical check is made and if in good proportion the steel is ready for tapping into the ladle. Low carbon steels as mentioned above must not be held too long in the hearth otherwise they will oxidize or "burn." To prolong the working period we add pig iron, ferro manganese, or spiegel and attempt to get the required amount of carbon at the point of tapping or "on the way down" as is the common expression. The average sheet steel will run 0.10 per cent carbon and a carbon content as low as this or even lower, as is often specified, requires careful working of the charge. If the carbon is caught on the way down we add no carbon to the ladle only the other chemical ingredients deficient at the point of tapping. A long steel rod is rammed through the bath which pushes out the retaining plug and the steel flows down the spout and into the ladle.

Thus in one continuous operation we have converted, by refining, a mass of metal into steel suitable to be mechanically worked to the shape intended. This in general constitutes a heat and usually bears a number which is ultimately stamped on the finished sheet. This heat number is of little importance to the consumer but is a useful reference to the manufacturer in case of a complaint on excessive breakage or an order calling for a repeat of the same heat. A record of this heat gives a ready index as to its chemical analysis. The time taken for a heat (refer to Table I) is the time from the tapping of the previous heat to the tapping of the one just described.

### Teeming Into Ingots

The refined metal flows into the ladle at a temperature around 1600 deg. C. (2912 deg. F.) and the ladle is then swung over molds which vary in capacity from 3200 to 6000 lb. This teeming into molds is carefully watched as numerous surface defects such as scabs and slivers appear on the surface of ingot which are very objectionable and give rise to a high rejection of sheets at the inspection department. Steel or other shapes such as structural iron will pass on a certain amount of such surface defects but sheets being rolled to such thin sections and exposed to such a rigid surface inspection must be practically free from them.

The nozzle of the ladle is placed over the center of the mold, the stopper raised and the steel flows into the mold below. Care must be taken to prevent the splashing of steel on the cold sides of the mold which are the cause of slivers. The temperature of the steel at this point is about 1512 deg. C. (2753 deg. F.) and being filled with dissolved gases now trying to escape cause a certain amount of "wildness" which is reduced somewhat by the addition of aluminum in small round pieces called shot. As only a few ounces are added per ingot the aluminum has little or no

effect on the ultimate physical properties of the steel. The steel first cools very rapidly on the sides of the mold and this outer surface of the resulting ingot is called the "skin." As it cools from the skin towards the center crystallization of the steel takes place and rapidly grows toward the center and the top. This is known as "rimming in" and its rate is more rapid the lower the temperature of the steel when teemed into the mold.

When about half of the molds have been filled a small ladle of the steel is obtained which is analyzed and this constitutes the recorded chemical analysis of the heat. Following the teeming of the steel the ingots are allowed to set or crystallize from one-half an hour to two hours depending on their size, after which the mold is stripped or pulled off over the ingot. The ingots then go to the ingot furnaces or to a reverse pile or "bank" for future use.

(To be continued)

## A Newly Constructed Seamless Tube Mill

(Continued from page 241)

### Thrust Block Bearing

As extremely heavy thrust loads were anticipated on a mill of this size, considerable thought and time were given to the design of the thrust block bearing. The spindle is carried on two Timken bearings, the front bearing (one next to mill) is 25½ in. O. D. x 12-in. base and has a rated capacity of 584,000 lbs. thrust and 175,000 lbs. radial loads at 300 rpm. The tail bearing is approximately 16½ in. O. D. x 8-in. base. The spindle is made of forged nickel chrome steel, bored for the passage of the piercing bar cooling water, and has a heavy forged flange half coupling on the front end to carry the piercing head bar. The large bearing was forced into its seat in the barrel with 40 tons on the press. The bearings are lubricated by forced feed, the oil being handled by a pump of 10 gal. per minute capacity at 300 rpm. of the spindle, mounted in the barrel, entirely submerged in the oil and driven from a gear mounted on the spindle. The pump is securely mounted to withstand the shock from the travel of the barrel. The barrel has an oil capacity of 40 gals., water cooled, the piercing head cooling water first passing through a copper pipe coil submerged in the oil. The thrust block bearing is designed to operate with a temperature rise not to exceed 30 deg. F. at maximum load. The thrust block bearing weighs about 16,000 lbs., and has a travel of approximately 38 ft., moved by an air cylinder, the piston rod being carried on cast iron rollers mounted on Hyatt roller bearings in the thrust block slide. The thrust block slide is in two sections of heavy cast steel with the ways lined with C. R. S. liners. The two sections are well ribbed and tied together with spring cushion stops on the back casting, which also carries an extension to which is securely connected the thrust block pusher cylinder. This cylinder is made of heavy seamless tube, bored for the piston fit and the piston is of cast iron with special rings.

Forced feed oil or pressure gun grease lubrication is used throughout the entire mill, even down to the wrist pins on the smallest air cylinder connecting rods, the same grease gun fitting all connections.

# The Evolution of the Wide Strip Mill\*

An Engineer Intimately Acquainted with the History of Strip Mills Relates the Successive Developments in the Design of Mills and in the Practice of Rolling

By STEPHEN BADLAM†

THE outstanding achievement of the present decade, in the history of the rolling mill, is the development in the art of rolling wide, thin sections as exemplified by the wide strip mill and the continuous sheet mill.

The rolling of wide, thin sections has developed along two distinct and originally widely separated lines.

First—The rolling of strip, characterized by limitations in width and gage, rather than in length.

Second—The rolling of sheets, characterized by limitations in length, rather than in width and gage.

In 1924 strip was obtainable in widths up to 24 in. and in lengths as long as were demanded. Sheets were obtainable in widths as wide as were demanded (to about 54 in.), but were limited in length.

Strip was produced from billets and slabs, and in units from 100 lbs. up to 2,000 lbs. in weight, and was finished at delivery speeds up to 1,000 ft. per minute.

Sheets were produced from sheet bars, and in units from 12 lbs. up to 70 lbs. in weight, and were finished at delivery speeds of about 240 ft. per minute.

Strips were always rolled single, while sheets were generally rolled in "packs."

In the year 1924 a sheet mill was placed in operation that produced sheets by a continuous process, in widths up to 45 in. and in lengths up to 30 ft. In 1927 a product was placed on the market, in widths up to 36 in., having characteristics of both strips and sheets, but without the previously existing dimensional limitations of either. This new product approximates to strips in length, to sheets in width, and to both, in gauge and physical characteristics. For the purposes of this paper it will be designated by the term "broad strip" to distinguish it from what has been termed "wide strip" and which ranged from 12 in. to 24 in. in width.

During the present year two additional broad strip mills have gone into operation, and a third is well under way for the production of material 24 in. to 48 in. in width.

In its earliest stages, strip steel was merely a special product of the merchant bar mill, and was rolled, along with other thin, flat sections, such as pipe skelp, in the ordinary merchant mill. During the period from 1890 to 1900, however, the increasing demand brought it into the specialty class and special mills were built for its production.

This differentiation took place first in the narrower sizes, from 3 in. down to  $\frac{5}{8}$  in. wide, and from 16 gauge (.065 in.) to 22 gauge (.028 in.) in thickness, which were known as "hoop." The period from 1890 to 1896 was one of rapid development of the narrow mills, and by the latter year it was practically complete, culminating in the Morgan mill built for the

American Steel Hoop Company at the Upper Union Mills in Youngstown, Ohio. This mill was designed specially for the production of light hoop and cotton tie. It is still in operation, and for capacity and economy has hardly been exceeded to the present day.

The production of pipe skelp, 4 in. wide and over, was the next to separate from the parent stem, and this was followed by thinner gauges in the wider widths, which became known as band.

When the production of strip steel increased sufficiently to bring it into the ranks of a specialty, and mills were first built for its exclusive production, it was natural that they should be designed along the lines of the merchant mills with which their designers were familiar, and which had been producing the material.

An excellent example of the transition from the merchant mill to the strip mill is to be found in the Howard Avenue Plant of the American Tube & Stamping Company.

In the late eighties the Bridgeport Rolling Mill Company operated a merchant bar mill which was approximately one-quarter mile from The Wilmot & Hobbs Manufacturing Company's Cold Rolling Plant on Hancock Avenue. In 1893, The Wilmot & Hobbs Manufacturing Company, in order to supply themselves with raw material, purchased the Bridgeport Rolling Mill Company and undertook to roll strip on the merchant mill with what was at that time an unqualified success, producing strip up to 7 in. wide. The mill, as it existed at that time, consisted of 5 stands of 12-in. rolls in a line driven by one upright Corliss engine and was later changed to a 7-stand with the original Corliss engine on one end driving the first four stands and a triple expansion marine engine on the opposite end, driving the last three stands. This mill used a small 6-in. middle roll in the finishing stand and is the first example of the use of the backing roll principle in the hot rolling of strips of which we have any record.

This mill was operated until 1913 and then shut down and held as a spare until 1918, when it was scrapped.

The present Howard Avenue Mill was erected in 1900 as an 8-stand 16-in. mill for rolling wide sizes, 16-in. wide, down to 6 in., but was not a success as a mill for rolling wide sizes and has been remodeled several times and now consists of two stands of 16-in. roughing, three stands 14-in. intermediate and five stands 12-in. with the original steam drive which was on the 16-in. mill. This forms the Howard Avenue Mill of The Stanley Works, The American Tube & Stamping Plant, Bridgeport, Conn.

Another early mill of this type is the Bridgewater Mill of The Stanley Works, located at Bridgewater, Mass. This mill, as remodeled for rolling strip, consisted of three stands of 18-in. three-high rolls driven direct at 85 r.p.m. by an engine, and three stands of

\*Abstract of paper delivered before American Iron and Steel Institute, New York, October 28, 1927.

†Consulting engineer, Pittsburgh, Pa.



14-in. alternate two-high rolls, in line on the same shoes, and driven by a countershaft at 135 r.p.m. The maximum width rolled on this mill was 10 in.

Among the early mills owned by the American Steel Hoop Company are the No. 1 Mill at the Painter Works, which rolled as wide as 10¼ in. by 12 gauge (.109 in.) and the No. 3 Mill at the McCutcheon Works which early rolled wide skelp. The Painter mill has now been abandoned but the McCutcheon mill is still in operation. Both these mills were of the Belgian type with roughing and finishing trains on parallel lines, and about 40 ft. apart. The American Steel Hoop Company, prior to 1890 also owned a three-stand 20-in. bar mill in Warren, Ohio, which rolled bands up to 14½ in. by .140 in., in short lengths, however, probably not over 30 to 40 ft. This mill was dismantled shortly after 1900.

#### West Leechburg Steel Company 12-in. Mill

In 1901 the West Leechburg Steel Company built a 12-in. hot strip mill, that for width and thinness produced exceeded anything that had been attempted up to that time.

The mill consisted of nine stands of rolls, 12-in. diameter, in line, on the same shoes. The first five stands constituted the roughing, and the remaining four stands the finishing. The first four roughing stands were three-high and the fifth roughing stand and the first three finishing stands were alternate two-high, the last finishing stand had an extra friction-driven roll placed above the top roll of the three-high set. The middle and bottom rolls were dummies. These last five sets were all flat rolls, the piece receiving one pass in each.

#### Range of Sizes

|    |                                      |
|----|--------------------------------------|
| 20 | gage .035 in., 2½ in. to 4 in. wide  |
| 18 | gage .049 in., 2½ in. to 8 in. wide  |
| 16 | gage .065 in., 2½ in. to 10 in. wide |
| 14 | gage .083 in., 2½ in. to 12 in. wide |

#### Production

Best turn, 10½ hours, 134 tons  
Average monthly production, 3,500 tons

The above mills all represent an intermediate type and they were followed by mills designed to produce strip from 12 in. to 16 in. wide for which an insistent demand had developed by the early years of the present century.

#### American Tube & Stamping Company 16-in. Mill

The first mill definitely designed for the production of 16-in. wide strip was built by the American Tube & Stamping Company at Bridgeport, Conn., 1905. This was a semi-continuous mill and, as originally built, the roughing consisted of two parallel continuous trains, the piece passing through two stands of the first train, then back through one pass of the same train, was transferred laterally and passed through four passes of the second train. It was then transferred laterally, or looped through the two finishing stands. The last stand was three-high with a small middle roll, the bottom roll only being driven. One stand of the first continuous train and two stands of the second continuous train were provided with light vertical edging machines attached to the horizontal roll housings and driven through a slip coupling.

This mill was located in the same building as the blooming mill, the drive for the strip mill passing

under the roller run from the blooming mill to the bloom shear. Beyond the shear was a transfer by which hot slabs could be transferred to the rear of a continuous heating furnace, then passed through the furnace in an opposite direction to the strip mill.

This mill was driven by a single engine, 39 in. by 66 in. of 4000 h.p. through a primary and a secondary gear train, so arranged that the mill could be run at two different speeds by changing the spindles and coupling boxes, connecting the two gear trains, from one shaft to the other.

Pass Table

| Pass No. | Type                                          | Rolls Diameter | Length | Rpm.           | Distance to next pass |                                       |  |
|----------|-----------------------------------------------|----------------|--------|----------------|-----------------------|---------------------------------------|--|
| 1        | flat                                          | 16"            | 30"    | 34.9 to 50.3   | 5' 11¾"               | Engine<br>Hp.<br>4,000<br>Rpm.<br>100 |  |
| 2        | flat                                          | 16"            | 30"    | 46.6 to 67.1   |                       |                                       |  |
| 3        | vertical edger drops down, reverses direction |                |        |                |                       |                                       |  |
| 4        | flat                                          | 16"            | 30"    | 46.6 to 67.1   |                       |                                       |  |
|          | raised, lateral transfer, reverses direction  |                |        |                |                       |                                       |  |
| 5        | vertical edger                                |                |        |                |                       |                                       |  |
| 6        | flat                                          | 16"            | 30"    | 34.9 to 50.3   | 5' 11¾"               |                                       |  |
| 7        | flat                                          | 16"            | 30"    | 46.6 to 67.1   | 6' 8¾"                |                                       |  |
| 8        | vertical edger                                |                |        |                |                       |                                       |  |
| 9        | flat                                          | 16"            | 30"    | 75.1 to 108.1  | 5' 11¾"               |                                       |  |
| 10       | flat                                          | 16"            | 30"    | 100.0 to 144.1 |                       |                                       |  |
|          | lateral transfer, reverses direction          |                |        |                |                       |                                       |  |
| 11       | flat                                          | 16"            | 18"    | 100.0 to 144.1 |                       |                                       |  |
|          | lateral transfer or looping                   |                |        |                |                       |                                       |  |
| 12       | flat                                          | 16"            | 18"    | 100.1 to 144.1 |                       |                                       |  |
|          |                                               | 8"             |        |                |                       |                                       |  |

The original mill was very complicated in its arrangement and it was soon remodeled into a straight tandem roughing train of four flat passes and three vertical edgers, and a strand finishing train of four stands.

The raw material for the mill consists of slabs from 4¾ in. to 16 in. wide, by 1½ in. to 2 in. thick, and in lengths from 6 ft. up to 9 ft., heated in an oil-fired continuous furnace 10 ft. wide inside by 36 ft. 3 in. long. Slabs are charged into the furnace either hot, from the blooming mill shear, or cold, from the stock yard. Between the furnace and the first stand of the mill there is a slab shear for cutting into lengths suitable for the finished product.

Pass Table

| Pass No.                                              | Type                                 | Rolls Diameter | Length | Rpm.          | Distance to next pass |                                       |
|-------------------------------------------------------|--------------------------------------|----------------|--------|---------------|-----------------------|---------------------------------------|
| 1                                                     | vertical edger                       |                |        |               |                       | Engine<br>Hp.<br>4,000<br>Rpm.<br>100 |
| 2                                                     | flat                                 | 16"            | 30"    | 34.0 to 50.3  | 5' 11¾"               |                                       |
| 3                                                     | vertical edger                       |                |        |               |                       |                                       |
| 4                                                     | flat                                 | 16"            | 30"    | 46.6 to 67.1  | 6' 8¾"                |                                       |
| 5                                                     | vertical edger                       |                |        |               |                       |                                       |
| 6                                                     | flat                                 | 16"            | 30"    | 75.1 to 108.1 | 5' 11¾"               |                                       |
| 7                                                     | flat                                 | 16"            | 30"    | 100 to 144.1  |                       |                                       |
|                                                       | lateral transfer, direction reversed |                |        |               |                       |                                       |
| 8                                                     | flat                                 | 16"            | 18"    | 100 to 144.1  |                       |                                       |
| 9                                                     | flat                                 | 16"            | 18"    | 100 to 144.1  |                       |                                       |
| 10                                                    | flat                                 | 16"            | 18"    | 100 to 144.1  |                       |                                       |
| 11                                                    | flat                                 | 16"            | 18"    | 100 to 144.1  |                       |                                       |
|                                                       |                                      | 8"             |        |               |                       |                                       |
| lateral transfer or looping, stands 8 to 11 inclusive |                                      |                |        |               |                       |                                       |

lateral transfer or looping, stands 8 to 11 inclusive

#### Range of Sizes

|    |                                  |
|----|----------------------------------|
| 18 | gage .058 in., 4¾ in. to 6¾ in.  |
| 16 | gage .065 in., 4¾ in. to 10¾ in. |
| 14 | gage .083 in., 4¾ in. to 14 in.  |
| 12 | gage .109 in., 4¾ in. to 16 in.  |

#### Production

Best turn, 12 hours, 205 net tons  
Best monthly production, 5,300 net tons



Between the last stand of the continuous roughing and the first stand of the finishing there is a mechanical transfer, and between the other stands of the finishing the piece is either transferred or looped by hand.

Leaving the last stand of the mill the strip is delivered to a double cooling bed 9 ft. from center line of hot runout to center line of each cold runout and 95 ft. long. At the lower end of each cold runout is a flattener and a shear for cut-to-length stock and a coiler for material to be shipped in coils.

The mill, in its remodeled condition, has been very successful, producing strip from  $4\frac{3}{4}$  in. up to 16 in. in width and in all gages required for cold rolling. It is still in active operation, and is now owned by the Stanley Works, American Tube & Stamping Division.

#### Superior Steel Company, 16-in. Mill

In 1905 the Superior Steel Company, Carnegie, Pa., built a wide strip mill, which in its original design consisted of a single stand, three-high, universal rougher, followed by a five stand, alternate two-high strand train.

Pass Table

| Pass No. | Type                                 | Rolls Diameter | Length | Rpm.            | Distance to next pass | Engine or Motor Hp. | Rpm. |
|----------|--------------------------------------|----------------|--------|-----------------|-----------------------|---------------------|------|
| 1        | vertical edger                       | 20"            | 24"    | 30              | 8' $1\frac{3}{8}$ "   | ....                | .... |
| 2        | flat                                 | 20"            | 24"    | $7\frac{1}{4}$  | 7' $6\frac{3}{4}$ "   | ....                | .... |
| 3        | vertical edger                       | 20"            | 24"    | 25              | 4' $6\frac{3}{8}$ "   | 1000                | 120  |
| 4        | flat                                 | 20"            | 24"    | $16\frac{1}{2}$ | 7' $6\frac{3}{4}$ "   | ....                | .... |
| 5        | flat                                 | 20"            | 24"    | 30              | 17' $2\frac{3}{8}$ "  | 60                  | .... |
| 6        | vertical edger                       | 16"            | 20"    | 108             | 17' 6"                | ....                | .... |
| 7        | flat                                 | 16"            | 20"    | 110             | ....                  | ....                | .... |
| 8        | lateral transfer, reverses direction | 16"            | 20"    | 110             | ....                  | 3200                | 110  |
| 9        | flat                                 | 16"            | 20"    | 110             | ....                  | ....                | .... |
| 10       | flat                                 | 16"            | 20"    | 110             | ....                  | ....                | .... |
| 11       | flat                                 | 16"            | 20"    | 110             | ....                  | ....                | .... |

lateral transfer or looping between stands 8 to 11 inclusive

#### Range of Sizes

|         |          |                    |    |                     |
|---------|----------|--------------------|----|---------------------|
| 18 gage | .049 in. | $4\frac{1}{2}$ in. | to | 5 in.               |
| 16 gage | .065 in. | $4\frac{1}{2}$ in. | to | $9\frac{3}{4}$ in.  |
| 14 gage | .083 in. | $4\frac{1}{2}$ in. | to | 13 in.              |
| 12 gage | .109 in. | $4\frac{1}{2}$ in. | to | 16 in.              |
| 10 gage | .120 in. | $4\frac{1}{2}$ in. | to | $17\frac{1}{2}$ in. |

#### Production

Best turn,  $10\frac{1}{2}$  hours, 218 tons

The stock for this mill consisted of slabs from 5 in. to 17 in. wide, 3 in. thick, in lengths from 24 in. to 48 in. according to the thickness of the finished strip. The steel was heated in three regenerative gas-fired batch furnaces, each with a hearth 7 ft. by 18 ft. inside.

The roughing mill was not a success at the time, probably due to the construction of the universal stand and not to any inherent defect in the principle involved. In 1906 the roughing stand was taken out and replaced by a tandem train consisting of three flat passes and three edging passes (see Fig. 1). The three flat passes and the first two edging passes were driven by a 1,000 hp., 120 rpm. engine. The strand train was driven by a 2,000 hp. engine which was later replaced by a 3,200 hp., 110 rpm. engine. The third edger was driven by a 60 hp., d.c. motor.

This mill is peculiar in that the rolls of the continuous train are not driven through pinion stands, but the top roll of each pair is driven through the bottom roll by overhung gears on the outside wabblers ends away from the drive.

When the finished strip leaves the last stand of the mill it is delivered onto a cooling bed 112 ft. long by 11 ft. wide from center of hot runout to center of cold runout. One shear is provided for cut-to-length stock and a cropping shear and a reel for coiled material.

During the period from 1900 to 1910 several other mills were built for the production of thin, wide flats for various purposes and designed along various lines.

In 1902 the Youngstown Sheet & Tube Company built a mill for the production of skelp, which was in many ways the predecessor of the modern strip mill. This was their Skelp Mill No. 2. This mill consists of a three-high flat rougher, followed by a vertical edger and three 16-in. two-high stands, in tandem, spaced far enough apart, however, so that the piece is never in more than one stand of rolls at a time. This mill showed the tremendous tonnage possibilities of the continuous type of mill, running as high as 20,000 tons per month of skelp from 7 in. to  $22\frac{3}{4}$  in. wide.

In 1906 a mill was designed by Julian Kennedy for the Cambria Steel Company, for the production of

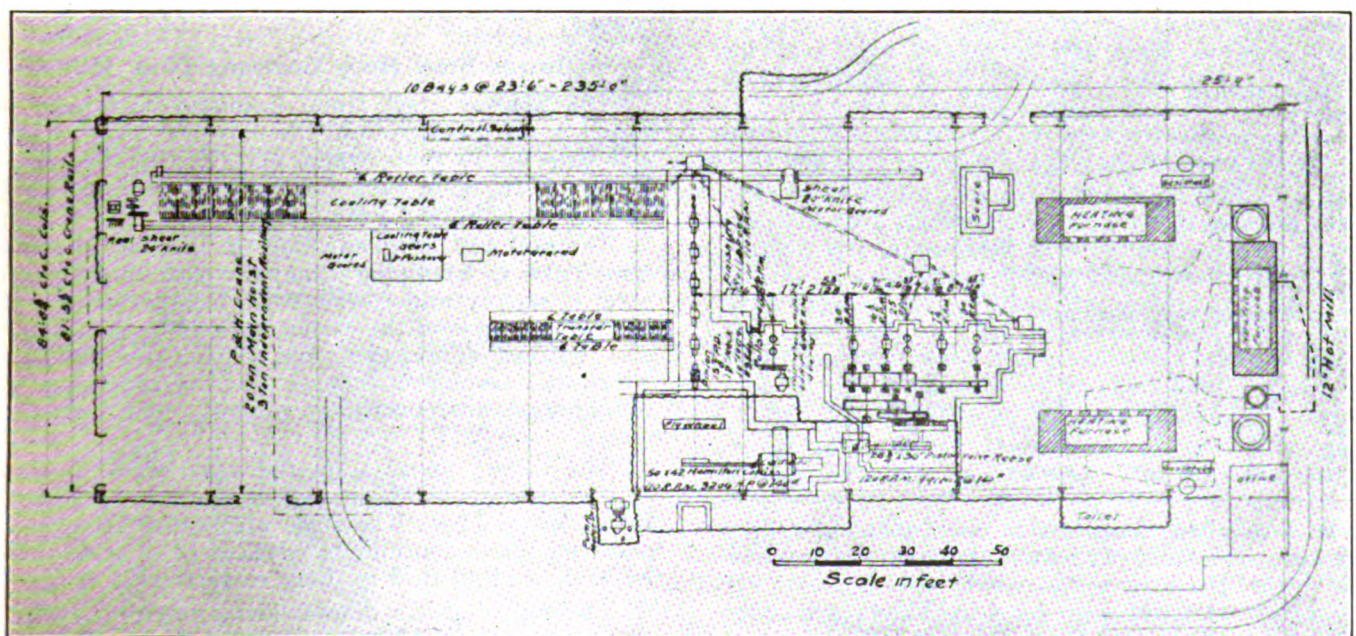


FIG. 1—16-in. Strip mill. Superior Steel Corporation, 1905.



light gage plates for the manufacture of agricultural shapes, such as coulter and harrow discs, plow plates, etc.

This mill consists of a two-high reversing, universal roughing mill, with vertical rolls on both sides, driven by a direct-connected, three-cylinder engine. The universal mill is followed by a finisher consisting of two stands of 22-in. flat rolls, each two-high, with the pinion stand between. The piece receives one pass in the first stand, then is transferred laterally and receives a pass in the second stand, in the opposite direction.

This mill rolls flat from 6 in. by .187 in. up to 36 in. by  $\frac{1}{4}$  in. and heavier, in lengths up to 90 ft., with an average tonnage of 7,000 tons per month.

The Harrisburg Pipe & Pipe Bending Company built a mill for the production of light plates which has since been used for rolling strip from 4 in. to 18 in. wide in the usual range of gages.

The mill consists of a horizontal edger, followed by a three-high 20-in. universal rougher, and this followed by a three-high 21-in. finisher. All three stands are in one straight line, the piece passing directly from one stand to the next and receiving from three to seven passes in a stand with the exception of the horizontal edger, which is a single pass only.

The rougher is driven by a steam engine and the finisher by a 1,200 hp., constant, a.c. motor. The horizontal edger is driven by a 200 hp. motor.

#### American Steel & Wire Company, 14-in. Mill

The American Steel & Wire Company at this time was the largest producer in the country of flat wire, as the narrower sizes of cold rolled strip steel were called, but were without the facilities for hot rolling any but the narrower widths.

In 1907-8 they built a mill at their, then new, Cuyahoga Works, designed especially for the produc-

These were heated in a by-product, or producer, gas-fired, continuous furnace, 8 ft. 3 in. wide inside by 50 ft. long. The heated slabs were discharged onto a roller run, and then turned 90 deg. by a turntable to go to the mill. Between the turntable and the first stand of the mill is a scale breaker consisting of a pair of corrugated rolls.

The mill consists of a continuous roughing train, originally of six stands, and later of seven stands, and a strand finishing train of three double-duos and a bullhead. Two additional bullhead stands are located in tandem with the first, making three continuous in the finishing.

The mill was originally driven by three motors, one 1,800 hp., constant speed, a.c. motor driving the roughing through ropes, line shaft, and bevel gears, and the double-duo direct, and two 800 hp., adjustable speed, d.c. motors driving the last two stands. To this was later added one 600 hp., adjustable speed, d.c. motor to drive the first bullhead stand.

Leaving the last pass of the mill the strip was originally turned up on edge and delivered on a run-out plate by a vibrator and then coiled on two vertical reels, no cooling bed or means for handling straight

#### Range of Sizes

|         |                                                    |
|---------|----------------------------------------------------|
| 18 gage | .049 in., $2\frac{1}{8}$ in. to 4 in.              |
| 17 gage | .058 in., $2\frac{1}{8}$ in. to 5 in.              |
| 16 gage | .065 in., $2\frac{1}{8}$ in. to $6\frac{3}{4}$ in. |
| 14 gage | .083 in., $2\frac{1}{8}$ in. to $9\frac{7}{8}$ in. |

#### Production

|                          |              |
|--------------------------|--------------|
| Best turn, 10 hours..... | 150.8 tons   |
| Best day .....           | 277.4 tons   |
| Best week.....           | 1,276.0 tons |
| Best month .....         | 5,263.0 tons |

stock being provided. In 1921, however, a cooling bed 208 ft. long by 12 ft. wide was added and the two reels were placed at the lower end of the hot runout.

This mill was novel in many respects: it was the first wide strip mill to be driven by electric power; it was the first application of the double-duo, in this country at least, to the rolling of strip; it was the first application of the tandem finisher as applied to strip rolling.

#### Sharon Steel Hoop Company 14-in. Mill

The Sharon Steel Hoop Company had been engaged in the production of the narrower sizes of hoop and strip for 10 years when, in 1910, they decided to build a 14-in. wide band mill which went into operation in the following year.

The mill was designed along the lines of the American Tube & Stamping Company and the Superior Steel Company mills, some few changes being made from the designs of the earlier mills. The steam drive was replaced with electric, and some of the drawbacks which had developed, such as too close spacing of the roughing stands, overhung pinions, etc., were corrected.

The rolling starts from the usual sizes of slabs, 4 in. to 15 in. wide,  $1\frac{3}{4}$  in. to 3 in. thick, and in lengths from 2 ft. to 11 ft. The slabs are heated in two producer gas-fired, continuous furnaces 12 ft. wide inside by 35 ft. and 46 ft. 5 in. long respectively.

The mill consists of a tandem roughing train of three flat passes and two edging passes, and a finishing train of five stands in line.

Pass Table

| Pass No. | Type                                   | Rolls Diam.        | Length | Rpm.    | Distance to next pass | Motor Hp. | Rpm.    |
|----------|----------------------------------------|--------------------|--------|---------|-----------------------|-----------|---------|
| 1        | flat                                   | 16"                | 24"    |         |                       |           |         |
| 2        | flat                                   | 16 $\frac{1}{2}$ " | 24"    | 19.4    | 5' 4"                 |           |         |
| 3        | flat                                   | 16 $\frac{1}{2}$ " | 24"    | 26.2    | 5' 4"                 |           |         |
| 4        | flat                                   | 17"                | 24"    | 38.3    | 10' 0"                |           |         |
| 5        | flat                                   | 17"                | 24"    | 58.3    | 16' 0"                |           |         |
| 6        | flat                                   | 17"                | 24"    | 82.0    | 26' 6"                |           |         |
| 7        | horizontal edger                       | 17"                | 24"    | 130.0   | 32' 10"               |           |         |
| 8        | flat                                   | 14"                | 24"    | 214     |                       |           |         |
|          | direction reversed                     |                    |        |         |                       |           |         |
| 9        | horizontal edger                       | 14"                | 24"    | 214     |                       | 1000      | 214     |
|          | vertical repeater                      |                    |        |         |                       |           |         |
| 10       | flat                                   | 14"                | 24"    | 214     |                       |           |         |
|          | direction reversed                     |                    |        |         |                       |           |         |
| 11       | flat                                   | 14"                | 24"    | 214     |                       |           |         |
|          | Slick repeater, piece turned over      |                    |        |         |                       |           |         |
| 12       | flat                                   | 14"                | 24"    | 214     |                       |           |         |
|          | horizontal repeater, piece turned over |                    |        |         |                       |           |         |
| 13       | flat                                   | 14"                | 24"    | 214     |                       |           |         |
|          | hand looping                           |                    |        |         |                       |           |         |
|          |                                        | Rolls Diameter     | Length | Rpm.    | Distance to next pass | Motor Hp. | Rpm.    |
| 14       | flat                                   | 12 $\frac{1}{2}$ " | 16"    | 150-250 | 12' 0"                | 600       | 150-250 |
| 15       | flat                                   | 13"                | 16"    | 210-315 | 15' 0"                | 800       | 210-315 |
| 16       | flat                                   | 13"                | 16"    | 260-390 |                       | 800       | 260-390 |

tion of hot rolled strip steel in coils, for cold rolling purposes. This mill was first operated February 4, 1909.

For raw material 4-in. by 4-in. billets and slabs from 5 in. to 10 in. in width,  $2\frac{1}{2}$  in. to  $3\frac{3}{4}$  in. thick, and in lengths from 44 in. up to 90 in. were used.



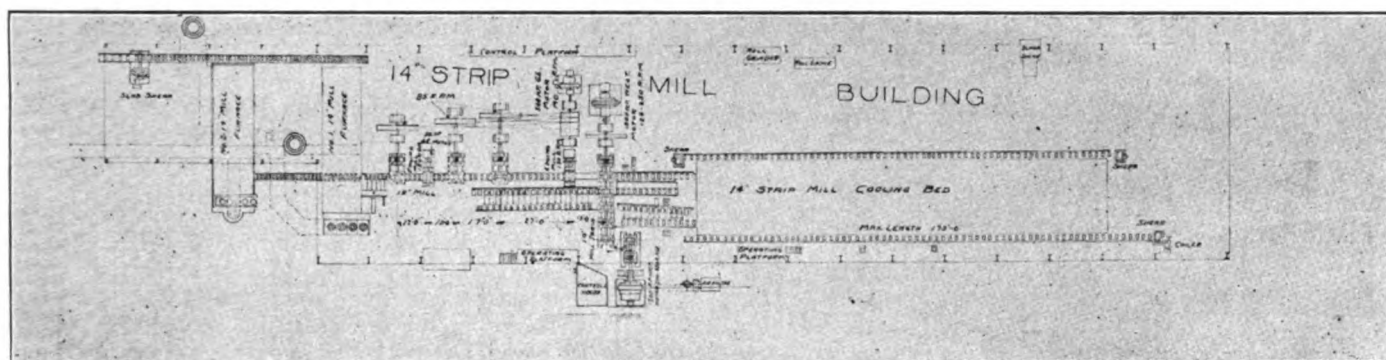


FIG. 2—14-in. Strip mill. Sharon Steel Hoop Company, 1927.

The mill was driven by two motors, one 500 hp., constant speed, a.c. motor driving the roughing stands by means of ropes, and one 1,500 hp., adjustable speed, d.c. motor driving the five finishing stands

Pass Table

| Pass No.                                                     | Type           | Rolls Diameter | Length | Rpm.    | Distance to next pass                | Hp. | Motor Rpm.   |
|--------------------------------------------------------------|----------------|----------------|--------|---------|--------------------------------------|-----|--------------|
| 1                                                            | flat           | 18"            | 22"    | 85      | 12' 0"                               | 500 | 190          |
| 2                                                            | vertical edger |                |        | 150     | 10' 0"                               |     |              |
| 3                                                            | flat           | 18"            | 22"    | 85      | 17' 0"                               |     |              |
| 4                                                            | flat           | 18"            | 22"    | 85      | 27' 0"                               |     |              |
| 5                                                            | vertical edger |                |        | 150     | 13' 0"                               | 50  | 1500 125-250 |
| 6                                                            | flat           | 14"            | 18"    | 125-250 | lateral transfer, reverses direction |     |              |
| 7                                                            | flat           | 14"            | 18"    | 125-250 |                                      |     |              |
| 8                                                            | flat           | 14"            | 18"    | 125-250 |                                      |     |              |
| 9                                                            | flat           | 14"            | 18"    | 125-250 |                                      |     |              |
| 10                                                           | flat           | 14"            | 18"    | 125-250 |                                      |     |              |
| lateral transfer or looping between stands 7 to 10 inclusive |                |                |        |         |                                      |     |              |

Range of Sizes

|         |                                  |
|---------|----------------------------------|
| 16 gage | .065 in., 3½ in. to 8 in. wide   |
| 14 gage | .083 in., 3½ in. to 12 in. wide  |
| 12 gage | .109 in., 3½ in. to 15½ in. wide |
| 10 gage | .134 in., 3½ in. to 15½ in. wide |

Production

|                        |                 |
|------------------------|-----------------|
| Best turn, 8 hours.... | 272 net tons    |
| Best day, 24 hours.... | 713 net tons    |
| Best month.....        | 11,270 net tons |

direct. The two vertical edgers are each driven by a 50 hp., constant speed, d.c. motor. Total horsepower, 2,100.

The finished strip is delivered to a single cooling bed 31 ft. 10 in. from center of hot runout to center of cold runout, and 160 ft. long. Two shears are provided for cutting to length, one at each end of the cold runout, and a cropping shear and reel at the end of the hot runout for stock to be furnished in coils.

Pass Table

| Pass No.                                                     | Type           | Rolls Diameter | Length | Rpm.    | Distance to next pass | Hp.  | Motor Rpm. |
|--------------------------------------------------------------|----------------|----------------|--------|---------|-----------------------|------|------------|
| 1                                                            | flat           | 18"            | 22"    | 85      | 12' 0"                | 500  | 190        |
| 2                                                            | vertical edger |                |        | 150     | 10' 0"                |      |            |
| 3                                                            | flat           | 18"            | 22"    | 85      | 17' 0"                |      |            |
| 4                                                            | flat           | 18"            | 22"    | 85      | 27' 0"                |      |            |
| 5                                                            | vertical edger |                |        | 150     | 13' 0"                | 50   |            |
| 6                                                            | flat           | 14"            | 18"    | 125-250 | }                     | 1500 | 125-250    |
| lateral transfer, reverses direction                         |                |                |        |         |                       |      |            |
| 7                                                            | flat           | 14"            | 18"    | 125-250 |                       |      |            |
| 8                                                            | flat           | 14"            | 18"    | 125-250 |                       |      |            |
| 9                                                            | flat           | 14"            | 18"    | 125-250 |                       |      |            |
| 10                                                           | flat           | 14"            | 18"    | 125-250 | 9' 0"                 | 1200 | 200-400    |
| 11                                                           | flat           | 14"            | 18"    | 200-400 |                       |      |            |
| lateral transfer or looping between stands 7 to 10 inclusive |                |                |        |         |                       |      |            |

During the year 1927 the mill was remodeled by the addition of a new stand of finishing rolls, in tandem with the old finisher driven by an independent, adjustable speed, d.c. motor of 1,200 hp. (See Fig. 2.)

By 1915 the rapid growth of the metal stamping and forming industry, the replacement of cast parts by stampings, and the increasing demands of the automobile manufacturers, as well as the war requirements, led to a demand for strip steel largely exceeding the supply.

The natural result was a wide extension of the strip steel industry with increase in capacity of those concerns already in the business, with the addition of strip to their lines by several other concerns, and one new concern coming into the field.

#### Weirton Steel Company 16-in. Mill

In 1915-6 the Weirton Steel Company commenced the construction of a hot strip mill for range and capacity, represented an advance over anything previously attempted. The mill was first operated December 23, 1916.

Slabs from 5 in. to 16 in. wide, 3 in. thick, and in lengths up to 11 ft. formed the raw material for the mill and were heated in a producer gas-fired, continuous furnace 12 ft. inside and 40 ft. 1½ in. long.

The mill comprised a tandem roughing train of four stands of which the first and fourth were horizontal edgers, the piece entering in a vertical position, the idea being to allow the scale loosened by the edging pass to fall clear of the piece, and not be rolled in during the next flat pass. It also had the effect of turning the piece over between two flat passes.

Following the fourth pass was a lateral transfer to a flat pass and a vertical edger, then a second lateral transfer to a double-duo stand with two flat passes, a third lateral transfer to a second double-duo with two flat passes, and a fourth lateral transfer to a bull-head finisher. Back of the first double-duo was a run-out table and back of the second double-duo was a repeater that turned the piece over, around a drum, and then back into the other pair of rolls of the duo.

The mill was driven by three motors, a 1,500 hp., constant speed, a.c. motor geared to the roughing and intermediate, a 2,500 hp., adjustable speed, a.c. motor geared to the two double-duos, and an 800 hp., adjustable speed, a.c. motor geared to the bullhead. The vertical edger was driven by a 100 hp., adjustable speed, d.c. motor. The total horsepower was 4,900.

Leaving the last pass of the mill the strip was delivered to a double cooling bed, 13 ft. from center line of hot runout to center line of each cold runout,

and 250 ft. long. Two shears and gage tables were provided for cutting to length, and a cropping shear and reel for coiled stock in line with the hot runout.

| Pass Table |                                                  |                |        |         |                       |                |
|------------|--------------------------------------------------|----------------|--------|---------|-----------------------|----------------|
| Pass No.   | Type                                             | Rolls Diameter | Length | Rpm.    | Distance to next pass | Motor Hp. Rpm. |
| 1          | horizon'l                                        |                |        |         |                       |                |
|            | edger                                            | 20"            | 24"    | 12.5    | 20' 0"                | 1500 505       |
| 2          | flat                                             | 20"            | 24"    | 11.8    | 8' 0"                 |                |
| 3          | flat                                             | 20"            | 24"    | 20.2    | 48' 6"                |                |
| 4          | horizon'l                                        |                |        |         |                       |                |
|            | edger                                            | 20"            | 24"    | 21.4    |                       | 100 585        |
|            | lateral transfer, turnover, direction reversed   |                |        |         |                       |                |
| 5          | flat                                             | 20"            | 24"    | 32.0    | 21' 6"                |                |
| 6          | vertical                                         |                |        |         |                       |                |
|            | edger                                            | 19"            | 6"     | 35.7    |                       | 2500 180-360   |
|            | lateral transfer, turnover, direction reversed   |                |        |         |                       |                |
| 7          | flat                                             | 16"            | 20"    | 120-240 |                       |                |
|            | runout table, direction reversed                 |                |        |         |                       |                |
| 8          | flat                                             | 16"            | 20"    | 120-240 |                       | 800 300-600    |
|            | lateral transfer, direction reversed, or looping |                |        |         |                       |                |
| 9          | flat                                             | 16"            | 20"    | 120-240 |                       |                |
|            | horizontal repeater, piece turned over           |                |        |         |                       |                |
| 10         | flat                                             | 16"            | 20"    | 120-240 |                       |                |
|            | lateral transfer, direction reversed, or looping |                |        |         |                       |                |
| 11         | flat                                             | 16"            | 20"    | 136-272 |                       |                |

#### Range of Sizes

|         |                           |
|---------|---------------------------|
| 18 gage | .049 in., 5 in. to 6½ in. |
| 16 gage | .065 in., 5 in. to 10 in. |
| 14 gage | .083 in., 5 in. to 13 in. |
| 12 gage | .109 in., 5 in. to 15 in. |
| 11 gage | .120 in., 5 in. to 16 in. |

#### Production

|                        |            |
|------------------------|------------|
| Best turn, 8 hours.... | 185 tons   |
| Best day, 24 hours.... | 479 tons   |
| Best month.....        | 8,365 tons |

In 1920 the mill was entirely remodeled. A second furnace was added, a horizontal slab shear was installed between the furnace and the first stand of rolls. The continuous rougher was redesigned by the addition of a vertical edger, a flat pass, and a vertical edger following stand No. 3. Old stand No. 4 was changed to a flat pass, disconnected from the roughing motor and driven by the 800 hp motor formerly on the finishing.

#### Range of Sizes

|                | 1916-20    | 1920-5     | 1925-7     |
|----------------|------------|------------|------------|
| Horse power... | 4900       | 6300       | 8500       |
| 18 gage .049"  | 5" to 6½"  | 5" to 6½"  | 5" to 6½"  |
| 16 gage .065"  | 5" to 10 " | 5" to 10 " | 5" to 11 " |
| 14 gage .083"  | 5" to 13 " | 5" to 13 " | 5" to 17½" |
| 12 gage .109"  | 5" to 15 " | 5" to 15 " | 5" to 19 " |
| 11 gage .120"  | 5" to 16 " | 5" to 19 " | 5" to 22 " |

#### Production

|                     | 1916-20    | 1920-5      | 1925-7      |
|---------------------|------------|-------------|-------------|
| Horse power .....   | 4,900      | 6,300       | 8,500       |
| Best turn, 8 hours. | 185 tons   | 231 tons    | 275 tons    |
| Best day, 24 hours  | 479 tons   | 644 tons    | 639 tons    |
| Best month .....    | 8,365 tons | 11,386 tons | 13,658 tons |

In 1925 the mill was again remodeled and a new roughing drive installed. The 800 hp. motor on the last stand of the continuous rougher was replaced by a new 1,500 hp., constant speed, a.c. motor. A new stand, No. 8, driven by a new 1,500 hp., adjustable speed, a.c. motor was added before the first double-duo. A repeater was added between the second double-duo and the finisher, making the mill automatic throughout. Total horsepower, 8,500.

It is interesting to note the production and range of sizes of the mill during the three periods and their correlation to the horsepower.

## Iron Ore Industry Records Decrease in Output and Value in 1927

The iron ore mined in the United States in 1927, exclusive of ore that contained five per cent or more of manganese in the natural state, is estimated by the United States Bureau of Mines, Department of Commerce, at 61,778,000 gross tons, a decrease of nine per cent as compared with that mined in 1926. The ore shipped from the mines in 1927 is estimated at 61,325,000 gross tons, valued at \$153,641,000, a decrease of 11 per cent in quantity and of 12 per cent in total value as compared with the figures for 1926. The average value of the ore per gross ton at the mines in 1927 is estimated at \$2.51; in 1926 it was also \$2.51. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, apparently increased from 9,565,880 gross tons in 1926 to 10,044,000 tons in 1927, or five per cent.

The Bureau of Mines estimates are based on preliminary figures furnished by producers who in 1926 mined about 99 per cent of the total iron ore. They show the totals for the principal iron-ore producing states, and, by grouping together certain states, the totals for the Lake Superior district and for groups of southeastern, northeastern, and western states.

### Lake Superior District

About 83 per cent of the iron ore shipped in 1927 came from the Lake Superior district, in which approximately 51,691,000 gross tons were mined and 51,183,000 tons were shipped, decreases of 10 and 13 per cent, respectively, as compared with the quantities mined and shipped in 1926. The ore shipped in 1927 was valued at \$130,453,000, a decrease of 14 per cent. These totals include the ore from mines in southern Wisconsin and ore shipped by rail as well as by water from small mines, but exclude magniferous ores amounting to approximately 1,302,000 gross tons in 1927 and 1,065,419 tons in 1926 that contained five per cent or more of manganese in the natural state. The ore is chiefly hematite. The stocks of iron ore in this district apparently increased from 8,208,713 gross tons in 1926 to 8,759,000 tons in 1927, or seven per cent. The stocks at the end of 1927 were about 655,000 tons less than the average for the preceding five years. The shipments of iron ore by water from the Lake Superior district in 1927 (including magniferous iron ores), according to the Lake Superior Iron Ore Association, amounted to 51,107,136 gross tons, a decrease of 13 per cent as compared with these shipments in 1926. The average value of the ore at the mines in the Lake Superior district in 1927 was \$2.55 a ton; in 1926 it was \$2.56.

### Southeastern States

The southeastern states, which constitute the second largest iron-ore producing area, including the Birmingham and Chattanooga districts, mined approximately 6,832,000 gross tons of iron ore in 1927, a decrease of five per cent as compared with 1926. The shipments of iron ore from mines in these states in 1927 amounted to 6,866,000 gross tons, valued at \$14,016,000, decreases of five and seven per cent, respectively, in quantity and value as compared with 1926. The ore is mainly hematite; brown ore and magnetite come next in order. The average value of the ore produced in these states in 1927 per gross ton was \$2.04; in 1926 it was \$2.07.

# Developments in Metallurgy During 1927

Among Topics Considered Are: Ferrous Metallurgy, Centrifugal Casting, Silicon Alloys, Welding, Application of X-Rays, Chromium Plating and Non-Ferrous Metallurgy

By JAMES SILBERSTEIN, Ph.D.\*

A SURVEY of developments in the field of metallurgy during the past year reveals much of interest. The needs for new and better materials is of great importance. The ever increasing requirements of a highly industrialized civilization have created demands for materials to withstand stress and corrosion at elevated temperatures to an extent which has heretofore never been thought of. A large amount of research investigation and testing work has been done to develop materials which will meet the properties required.

## Ferrous Metallurgy

**Melting furnaces**—The compounding of metals and alloys of high quality is becoming more important, and the application of the electric induction furnace for melting has increased considerably. The method of heating by induction has several important advantages among which are: The melting is very rapid; the heat is generated within the metal itself; a very thorough mixing is caused by the eddy currents, so that segregation is reduced to a minimum; no detrimental furnace gases are present; if desired the melting can take place in hydrogen, an inert gas or vacuum.

By melting and pouring in vacuum very high physical properties can be obtained. A nickel alloy melted in a 1000-lb. vacuum furnace and poured in vacuum gave an impact value (Charpy) of 100 ft. lb. per sq. cm.; while the same alloy melted in an electric arc furnace gave an impact value of only 24.5 ft. lb. per sq. cm.<sup>1</sup>

**Production of steel direct from ore**—Metallurgists in various parts of the world have long striven to repeat under modern conditions on an economic basis the ancient art of producing iron and steel direct from ores, avoiding the carburizing process in the blast furnace with the necessary later oxidation of excess carbon. A number of processes are being experimented with in almost every civilized country. Six papers on this subject were presented and discussed at the spring meeting of the American Electrochemical Society. So far as is known, none of the processes has been developed so that it can be conducted on a large scale production basis and compete with iron and steel, manufactured in the ordinary way.

**Centrifugal casting**—Centrifugal casting of cast iron pipe has been adopted in most countries. Compared with the old casting method the centrifugal one results in a denser structure, more rapid solidification and as a result hereof reduced segregation, greater strength and less cost. Centrifugal casting of steel bars offer also considerable advantages especially from a standpoint of cost.

**Steel**—Silicon steel containing up to .90 per cent silicon and .15 per cent carbon are being used in place of nickel steel for structural purposes, since they are cheaper and their strength and ductility characteris-

tics compare favorably with those of nickel steel. Nitrogenized steel has received considerable attention in this country since its first introduction from Germany. Special aluminum-chromium and aluminum-molybdenum steels are used for nitrogenizing. The process is conducted at a very much lower temperature than case hardening and it is claimed that as a result hereof considerably less distortion takes place. Investigations as to which applications are best served with nitrogenized steel are at present being conducted in this country.

**Cast iron**—By superheating molten cast iron a finely divided graphite structure in the resulting castings is produced and the physical properties are improved considerably. By superposing on this preliminary superheating the effects of alloying nickel and chromium with the iron and finally subjecting the finished casting to a special heat treatment a tensile strength of 70,000 to 100,000 lb. per square inch has been obtained.<sup>2</sup> Whilst it is true that these results were obtained on small laboratory melts, the data given show what it is possible to obtain with a properly treated cast iron.

**Iron—Silicon alloys**—Very interesting research work has been conducted on the iron silicon alloys, containing up to 25 per cent silicon by M. G. Corson.<sup>3</sup> One of his findings is that alloys containing up to 10.5 per cent silicon will forge if cast under suitable conditions. So far nothing above 5 per cent silicon has been considered suitable for forging. Since silicon sheet steels are used by the electrical industries, this and further research work on the iron silicon alloys will be of greatest importance for this industry. The chemical industry which uses iron silicon alloy castings on account of their corrosion resisting qualities will also be very much interested.

**Properties of very pure metals**—The preparation of very pure metals is of great importance from a scientific standpoint. The National Physical Society in England has succeeded in making a spectroscopically pure chromium, a 99.99 per cent pure manganese and a 99.94 per cent pure silicon. The chromium was prepared by electrolysis and subsequent purification in vacuum. Interesting is that the electrolytically produced chromium, which only contains hydrogen and oxygen as impurities has a Brinell hardness of 70 to 90.

The manganese, which was prepared by distillation in vacuum at a temperature slightly above its melting point, was very brittle. It was found to have four critical points in its solid state, namely at 1191, 1024, 742 and 682 deg. C.

Vanadium having a purity of 99.9 per cent has also been produced. It was found to be quite soft, ductile and malleable. The melting point was determined to 1700 deg. C.

**Welding**—The application of welding has progressed considerably in the past year. Structural steel welding

\*Metallurgical engineer, Material and Process Engineering Department, Westinghouse Electric & Mfg. Company.

<sup>1</sup>Zeitschrift für Metallkunde, 1927, p. 473.

<sup>2</sup>Paper presented at the conference of British Foundrymen by Prof. Piwowarsky, July, 1927.

<sup>3</sup>Iron Age, September 22, 1927.



is now assuming large proportions and there are few large firms engaged in the structural industry who are not using welding to some extent. The current application of welding to structural steel include buildings for both residential and industrial purposes, crane trolleys, part of bridges, towers and heavy machine bases and frames, and miscellaneous heavy machine parts. Welded steel as substitute for castings has made rapid progress on account of its advantages, among which are: Elimination of pattern expense, elimination of obsolete parts, reduction in weight, reduction in amount and cost of necessary machining and reduction in total material cost. As an example it may be mentioned that a welded steel frame for a heavy duty hydraulic press showed up to 66 per cent saving in cost.<sup>4</sup>

Welded piping is also used for many purposes since the elimination of mechanical joints results in economy of installations and increased efficiency.

*Atomic hydrogen welding process*—The phenomenon of dissociation of molecular hydrogen at high temperatures was discovered by Dr. I. Langmuir. The method developed to produce atomic hydrogen consists in blowing a stream of molecular hydrogen through an electric arc maintained between two tungsten electrodes. The temperature of the arc core is sufficient to dissociate the hydrogen. The produced atomic hydrogen diffuses from the arc core and recombines in the cooler regions into the molecular state forming an extremely hot flame. The evolved heat, of course, is the energy previously absorbed from the arc. The temperature of the atomic hydrogen flame is above 3700 deg. C. This temperature is maintained in a comparative small inner cone which is surrounded by the flame of reducing gas, with temperatures gradually falling to that of the outer mantle of the flame, where the recombined molecular hydrogen is burning in contact with air. This gradual change of temperature gives an extreme flexibility to the atomic hydrogen torch, so that very thin sections can be welded by this process. Another advantage is the suppression of oxidation, which is of great importance in the welding of steels containing such easily oxidizable elements as chromium.

*Application of X-ray*—A large increase of interest in the technical uses of X-rays has developed in the past year. Some of the most practical applications of X-ray methods are the following: Detection of flaws, blowholes and other defects in metals; determination of the presence or absence of preferred grain orientation and of internal strains; indication whether or not heat treatment or recrystallization has taken place; and determination of mechanical work upon single crystals and crystal aggregates. The chief advantage of X-ray method is that no cutting, polishing and etching is necessary; the disadvantages are the high cost and the limitation of the method to comparatively thin cross sections.

*Chromium plating*—The application of chromium plating has grown rapidly. On account of the hardness and tarnish resisting properties of chromium this process is admirably suited for decorative work. Since chromium is also characterized by excellent wearing qualities, chromium plating is applied with very good results to plug gauges, burnishing tools, files, etc.<sup>5</sup>

<sup>4</sup>The Welding Engineer, October, 1927, p. 29.

## Non-Ferrous Metallurgy

*Aluminum*—The year 1927 has witnessed a great increase both in the production and the consumption of aluminum. The lightness and strength of its alloys are features which have promoted its use not only in the aircraft industry where these characteristics are of paramount importance, but also in the automobile and railway industry, where a decrease in weight of moving parts is equivalent with a reduction in transportation cost.

The development of high strength aluminum alloys has progressed further and alloys with an ultimate tensile strength of up to 85,000 lb. per square inch have been made in this country and on the Continent.

The anodic oxidation of aluminum and its alloys for protection against corrosion has been investigated and several interesting papers published on this subject.<sup>6</sup>

One serious drawback to the use of duraluminum in aeroplane construction is its tendency to become brittle through intercrystalline corrosion when exposed to salt atmosphere. The United States Bureau of Standards has been experimenting with duraluminum in an effort to remove this disadvantage. It has been found that by giving duraluminum a protecting coating of unalloyed aluminum, the corrosion resistance is greatly increased. Sheets of duraluminum, coated with aluminum are now being produced on a commercial scale. A recent application of aluminum is the use of thin aluminum foil for heat insulating purposes. The insulation consists of layers of aluminum foil arranged concentrically around the subject to be insulated. An outer shell of sheet steel provides for sufficient strength. The advantage claimed for this insulation are its light weight and its low coefficient of heat transmission.

*Beryllium*—Although beryllium was discovered about 100 years ago, the production of this metal in quantities over a few grams was not successful until recently. Present production is based on an electrolytic reduction process, similar to the manufacture of aluminum though in the manufacture of beryllium a higher temperature of the electrolyte has to be maintained.

Pure beryllium has found a limited application in the construction of X-ray tubes. Its chief use will, however, be in form of alloys, since the pure metal is very hard and brittle and cannot be worked. A paper on the copper beryllium alloys was presented at the meeting of the Institute of Metal Division of the American Institute of Mining and Metallurgical Engineers, and the physical properties of alloys containing up to 1.60 per cent beryllium were given. Remarkably high physical properties of copper beryllium alloys have been reported from Germany. An alloy contained 2.5 per cent beryllium is claimed to have an ultimate tensile strength of 100,000 lb. per square inch and an elongation of 50 per cent in the annealed state. After heat treatment an ultimate tensile strength of 200,000 lb. per square inch and an elongation of two per cent have been obtained.<sup>7</sup> Such extraordinary high values have never before been recorded with a copper basic alloy and the copper beryllium alloys are therefore going to be of considerable importance

<sup>5</sup>Paper presented by W. N. Philips before the Society of Automotive Engineers at Detroit, 1927.

<sup>6</sup>Sutton and Sidery—The protection of aluminum and its alloys against corrosion, Journal, Institute of Metals, 1927, advance copy 439. Sutton and Willstrop—The nature of the film produced by anodic oxidation of aluminum, Journal, Institute of Metals, 1927, advance copy 440.

for the copper consuming industries as soon as the production becomes a commercial proposition.

**Bearing metals**—An alloy for which considerable interest has been shown and of which the application is steadily growing is the plastic bearing bronze, containing about 25 per cent lead, balance copper and tin. On account of the high lead content bearings of this alloy do not need babbit lining, which naturally is equal to a saving in cost. Other advantages are that bearings easily conform to the shaft and that no scoring of the shaft takes place, which is of importance from an economical point of view, since a scored shaft must be machined down and ultimately replaced, which entails a considerable cost.

**Copper**—By introducing in copper silicides of chromium, nickel or cobalt alloys, have been developed (the Corson alloys) which after heat treatment show interesting properties.<sup>8</sup> A copper-chromium-silicon alloy for instance has after being heat-treated and hard drawn an ultimate tensile strength of 80,000 lb. per square inch and an electric conductivity of 80 per cent of that of the internationally annealed copper standard. The heat treating of the Corson alloys confirms the theory of the hardening of the duraluminum, according to which submicroscopical particles precipitate in the alloy, imparting hardness and strength.

**Copper-cadmium alloys**—These alloys are being used in increasing quantities in cases where both high electrical conductivity and great strength are required. An alloy containing 1.1 per cent cadmium has in the hard drawn condition an ultimate tensile strength of 110,000 lb. per square inch and an electric conductivity of 91 per cent, while electrolytic copper has an ultimate tensile strength of 60,000 lb. per square inch and an electric conductivity of 100 per cent.

**Inverse segregation of bronzes**—The inverse segregation of certain bronzes has for a long time been subject for investigation of metallurgists. According to Genders<sup>9</sup> the following factors promote inverse segregation. The extent of the melting range, the occlusion of gases in the molten alloy, and the undercooling of the alloy. The inverse segregation is an important factor in the manufacturing of bronzes high in tin, while bronzes high in zinc are far less subjected to inverse segregation.

**Heat-treatment and precipitation hardening of non-ferrous metals**—Hardening as result of heat-treatment and subsequent precipitation of sub-microscopical particles has until recent times been found only in certain aluminum alloys. Considerable work has been conducted on other alloys and precipitation hardening properties have been discovered in a number of cases. Among these are the Corson copper alloys, beryllium copper alloys,<sup>10</sup> and silver copper alloys.<sup>11</sup> It is therefore to be expected that the heat treating of non-ferrous metals will be of great importance in the future.

**Thin metal films**—Metal films having a thickness of only four-tenths of a millionth of an inch (or equal

to the thickness of a layer of 25 atoms have been produced in Germany.<sup>12</sup> Among the metals were gold, silver, iron and nickel. The films are characterized by a comparatively high electric current carrying capacity and transparency for light, X-rays and cathode rays. They are of importance for scientific research on optical, electrical and other problems and also for investigations on the constitution of the atoms.

**Magnesium**—The use of magnesium and its alloys has increased considerably during the last year. Electron is a strong magnesium alloy which is 40 per cent lighter than duraluminum. This alloy has therefore found a wide application in aeroplane construction and other fields where reduction of weight is important. The use of electron in the construction of wheels for automobile omnibusses has resulted in a decrease in weight from 630 to 92 lb. No sign of wear of the electron parts could be found after 70,000 miles. Except for its light weight magnesium and its alloys have the advantage over aluminum in that it is much more resistant to corrosion by alkalis and hydrofluoric acid.

**Tin**—Tin is one of the more expensive useful metals and every effort to reduce the manufacturing cost of tin deserves careful attention. The gaseous reduction of tin concentrates in a semi-commercial manner has been studied by Colin G. Fink and C. L. Mantell.<sup>13</sup> Their findings were that present smelting cost, employing carbonaceous fuel is considerably more expensive than reduction with hydrogen would be. Another advantage of the latter process would be a considerable saving in refractories, since tin in the present reduction process is very damaging to almost all of the best refractories.

**Zinc**—Zinc having a purity of 99.9999 per cent has been produced for scientific purposes.<sup>14</sup> This very pure metal retains its metallic lustre for a considerable time while commercial zinc tarnishes quickly. It was found that the very pure zinc lost only .02 per cent of its weight in dilute hydrochloric acid, while a sample of high grade commercial zinc having the same weight and surface area dissolved entirely.

Very large zinc crystals, up to several inches in cross-section have been made by Prof. Mathewson and Phillips and studied as to the behavior under strain.<sup>15</sup> It was found that it was impossible to strain these crystals beyond the elastic limit without causing many twin crystals to form in the metal. This and other similar investigations are of great importance both from a metallurgical as well as a scientific point of view since they throw light on the nature of the metallic state and increase our knowledge on what happens when a metal is subjected to stress and strain.

<sup>12</sup>Paper presented by C. Miller at the meeting of the German Society of Metallurgical Engineers in Berlin, October, 1927.

<sup>13</sup>Paper presented at the meeting of the American Electro-Chemical Society in Philadelphia, April, 1927.

<sup>14</sup>Chemical and Metallurgical Engineering, May, 1927, p. 280.

<sup>15</sup>Paper read at the meeting of the Institute of Metals Division of the American Mining and Metallurgical Engineers, February, 1927.

### Efficacy of Open Hearth Slag

At a meeting of the American Society for Heat Treating held on February 2, in the U. S. Bureau of Mines Building, Pittsburgh, C. H. Herty, Jr., spoke on the "Refining Reactions of Slag in the Open Hearth Process."

<sup>7</sup>Zeitschrift für angew. Chemie, 1927, p. 1160. Also reported in a paper by G. Masing at the meeting of the German Society of Metallurgical Engineers in Berlin, October, 1927.

<sup>8</sup>Iron Age, 1927, p. 421.

<sup>9</sup>Paper presented at the spring meeting of the British Institute of Metals, 1927.

<sup>10</sup>Paper presented by O. Dahl at the meeting of the German Society of Metallurgical Engineers in Berlin, October, 1927.

<sup>11</sup>Paper presented by W. Fraenckel at the meeting of the German Society of Metallurgical Engineers in Berlin, October, 1927.

# Practice in Making Open-Hearth Steel

Suggestions Are Offered by a Man of Practical Experience as to  
the Effects of Iron Oxide, Manganese and Silicon.

Charge Considered in General

By C. W. VEACH\*

THE questions of the percentage of pig iron in the charge, and the analyses of the iron are fundamental to the basic open-hearth process. These two questions, and several others of like nature, are being thought of by a large number of open-hearth superintendents in many parts of the country at this time.

Before the questions of the percentage of pig iron we require in our charges can be answered we must understand the function which we expect the iron to perform. Why do we use costly pig iron when scrap steel—already nearly what we want in chemical composition, and requiring only to be melted and poured into the shapes we want, or into ingots to be forged or rolled into shape—can be bought for less money, and a lower melting loss is suffered?

Comparing the basic open-hearth charge with that of the acid open-hearth we find that the basic requires a higher percentage of pig iron to scrap than does the acid, and what is the reason? The reason is because a greater amount of oxygen is present in the basic bath than there is in the acid bath, requiring proportionately more carbon—or other reducing agent—to remove it.

Another reason there is more oxygen in the basic bath than there is in the acid is because the acid melts down level more quickly and is covered by the slag which prevents oxidation of the iron.

## Pig Iron Required

The question of how much pig iron we require to obtain best results must be determined by each melter because what is suitable for one may not be so for another. Local problems will help to decide for each melter the amount and the grade of pig iron he must use.

The condition of the furnace demands a greater or less amount of carbon in the bath to promote the stirring of metal and slag while the heat is being worked. Everything else equal the bath will heat up much more rapidly when the furnace is new than it will after the brickwork becomes worn thin, and the checkers begin to clog, therefore a less amount of carbon is required during the early part of the furnace campaign.

The action by which carbon is oxidized is endothermic, therefore no heat is conferred on the bath from this reaction. Yet we never would be able to get the metal much above its fusion temperature without the stirring action of the evolving carbonic oxides, for these gases set up currents similar in effect to the convection currents in a boiler. They bring the metal to the surface where it receives heat from the flame.

And in addition to bringing the metal to the surface where it finds contact (or nearly so) with the hotter flame, the escaping gases multiply the exposed surface many fold, and proportionately increase the rate of transfer of heat from flame to metal.

The chief function of pig iron is to supply carbon, silicon, and manganese which we must have to take

care of the oxygen in the charge. We might dispense with silicon, but carbon and manganese we must have in amounts sufficient so that when the metal is all melted we have a surplus of these elements to protect the bath while the heat is being shaped up for tapping.

It is my opinion that the residual manganese should be .30 per cent at least, and .35 per cent would not be too high. I think a high residual manganese is essential when the quality required in the product is such that the heats must be worked down under a partial equilibrium (there is no such thing as absolute equilibrium between slag and metal) between slag and metal in so far as the former affects the carbon of the bath.

It is apparent that manganese removes sulphur, and the statement made by more than one reliable authority that manganese breaks down iron-sulphur compounds and forms manganese sulphide instead has not yet been disputed. And what is of more importance to steel makers is the accepted fact that manganese sulphide is much less detrimental to steel than iron sulphide, yet its chances of coming to the surface where the compound is broken up and the sulphur either passes off as gas, or is taken up by the slag are good if conditions are propitious.

## Manganese Content in Pig

In view of the foregoing I advocate manganese content in pig iron of not less than 1.80 per cent and, if possible, over 2.00 per cent. Silicon should not be above 1.00 per cent, and is preferred as much lower as can be without affecting the iron in some other way.

Phosphorus and sulphur might well be dispensed with, but with the average grade of basic pig iron, especially the pig that is made from northern ores, these two elements should cause no trouble.

As I see it, the percentage of pig iron that any melter can most economically use is the amount that will afford the surplus of carbon he must have to finish his heats and tap them without reverting too often to the ore pile, or to the use of materials to bolster up the heat while getting it hot. In other words he should aim at a balanced charge so that the sequence of operation will conform to a pre-determined schedule without the several periods of the heat overlapping.

It would seem that we might have our heats melt more uniformly both in regard to time and carbon content. Also the residual manganese should vary less widely than it does, this would enable us to obtain more uniform results in the manganese content of the finished product.

## Manganese Oxide

What little we know of the solution theory of iron leads us to believe that manganese oxide does not exist in pig iron. Nor can we find anything in metallurgical literature which is opposed to this belief. One law of

\*Bettendorf, Iowa.



metallurgy may be cited to support our belief, and this law has been cited by Mr. J. E. Johnson, Jr., to show how manganese sulphide separates out from the iron and rises to the surface.

The law is this: "A metal will dissolve compounds of itself, but not compounds of another metal with anything like the same facility." In consequence of this law manganese oxide, having a much lower specific gravity than the iron, will rise to the surface.

### Iron Oxide

A trace of iron oxide may exist in any pig iron regardless of the conditions under which the iron is made, but the amount will not be sufficient to affect a basic open-hearth charge unless the blast furnace is off its normal working condition. That is, unless the blast furnace is unduly cold from a too cold blast, a deficiency of coke, or is taking water.

Two modern and eminent metallurgists, Dr. Richard Moldenke, and Mr. J. E. Johnson, Jr., both have studied iron oxide in iron, and its effect on the product which one or two processes produce, but which do very little refining, and that at a low temperature when compared with open-hearth temperatures. While the conclusions reached by these able students are at variance, one contending that iron oxide is deleterious in its effect and the other contending that it is beneficial, their arguments agree in one respect, namely, that iron oxide cannot possibly exist in any considerable amount in a bath rich in carbon, manganese, and silicon, and at a high temperature.

Many observant melters have no doubt witnessed a condition in the bath of metal when first melted where the metal was wild and full of gas yet when the test piece was broken it indicated high carbon. The test piece would show many worm holes, and this proved that the metal was saturated with gas—one of the oxides of carbon or iron oxide. We can hazard that such a heat would be covered with a slag which was also charged with iron oxide, and that if not allowed time to adjust itself, and was ored immediately a deficiency of carbon resulted.

But increase the temperature of such a heat, and by the time the slag is three-fourths liquid it will show a tremendous evolution of gases, and after only a few minutes of time elapses another test drawn out and broken will show that the carbon has dropped considerably, and the specimen shows that most of the gas has disappeared.

With a further rise in temperature each subsequent test will show a less amount of gas to exist, providing there is no deficiency of carbon, and if the residual manganese is .28 per cent or more the bath will lose every evidence of gas in so far as it shows in the test, and the uniform boil over the entire surface will show that carbon is uniting with the last traces of iron oxide and carbon monoxide is being dispelled.

### Carbon as an Oxidizing Agent

According to Johnson—quoted above—.05 per cent of carbon is more efficacious in removing iron oxide in a bath at 3,000 deg. than 3 per cent is at 2,300 deg., and we may take this to mean that with each increase in temperature the avidity with which carbon unites with oxygen increases correspondingly.

The foregoing I think supports my own contention that in the average basic pig iron there is not sufficient iron oxide—if there is any—to affect our basic operations noticeably, if at all.

Silicon reacts with oxygen at a low temperature and all but traces is oxidized by the time our basic heat is melted. It would be much better if the action between silicon and iron oxide could be deferred until considerable lime has come to the surface, for then the silicon dioxide would have a base to satisfy it and would not attack the hearth lining so greatly.

The problem confronting the open-hearth superintendent is the reduction of production costs, and he very intelligently wants to do this without sacrificing quality. Higher efficiency therefore is what we are seeking for, speeding up our operations and cutting corners wherever this is possible.

Making shortcuts and eliminating waste, and a more intelligent application of the principles of our processes are questions listed for the November meeting of the open-hearth committee. And benefits are bound to result to all who participate in a round-table discussion such as is conducted at these meetings.

### Eugene G. Grace Addresses Engineers

At the annual meeting of the Engineers Society of Western Pennsylvania, on January 30, the speakers of the evening were Eugene Grace, president of the Bethlehem Steel Corporation; E. H. Simmons, president of the New York Stock Exchange and Douglas Malloch of Chicago. The meeting which was held in the William Penn Hotel, Pittsburgh, was attended by approximately 1,400 members and guests; the largest number ever in attendance at an annual meeting of the society.

Mr. Grace spoke on the subject: "The Engineer as a Business Executive." He mentioned the following men as exemplifying the type of man to whom reference was made in the subject of his address: General Goethals, W. H. Atterbury, Herbert Hoover, John Hays Hammond and Charles Schwab. Each of these men, said Mr. Grace, possessed to a marked degree ability of a distinctly individual nature. To Mr. Atterbury was attributed the ability to think clearly and quickly; Mr. Hoover was accredited with the power to command loyalty, Mr. Hammond was alluded to as a philosopher and a business statesman, while Mr. Schwab was referred to as an optimist and a man of vision. In further reference to Mr. Schwab, Mr. Grace said, he had the characteristic of delegating power to subordinates and then insisting that that power was exercised.

The faculty to observe closely and accurately was emphasized as was the ability to correctly interpret one's observations. The ability to write correctly was also listed as one of the requirements that fitted an engineer for a position as executive.

Mr. Simmons related, how through the New York Stock Exchange, the securities of the steel companies were marketed and how necessary it was to have speculators as purchasers, especially in the formative period of a corporation. When the stocks of the United States Steel Corporation were first placed on the market the major portion of the total amount offered was acquired by speculators, but at present the amount held for speculative purposes is only a small percentage of the total issue. Mr. Simmons' address was of especial interest in that it made clear the function of the Stock Exchange in promoting the financing of industrial corporations.

Mr. Malloch's remarks were of a humorous nature.





Views in the Ford open-hearth plant at River Rouge.



# Technology Problems of the Steel Industry\*

## The Beneficiation of Iron Ores—The Selection and Cleaning of Coal—Utilization of Mine Wastes—Study of Coking Properties—By-Products of Coke Production

By WILLIAM A. FORBES†

PART II

TO meet the variety of problems presented in underground operations, much improvement in the operation has been made by installation of labor-saving devices, such as tugger hoists, mechanical slushers, and scrapers, in the use of which air-driven and electric double-drum hoists are employed, for conveying the ore from the working faces to chutes for transfer to main tramming levels.

One of the outstanding features of the present day has been the rapid change from steam operated to electrically operated mining equipment, and today most of the hoisting and pumping plants, and tramming machinery, on all the iron mining ranges are electrified. The mines are also electrically lighted.

*Beneficiation of Missabe Range Ores*—As the margins of the ore bodies, especially of the open pits, have been approached by mining operations, large masses of coarse ore and rock have been encountered, which brought an objection from the furnace operators, because of the large number and size of lumps in the ore delivered. To meet this problem, crushing and screening plants have been installed. The development of such plants was found necessary from the mining company standpoint also, because of the fact that these masses of lump ore greatly hindered and delayed steam shovel operations, requiring the avoidance of certain areas in the open pits in which such material predominates. The drilling and blasting, and subsequent further sledging of such large lumps in the open pits, to reduce them to acceptable sizes, was an unsatisfactory operation, for the reason that this work naturally consumed a large amount of labor and valuable operating time, and thus added considerably to the total producing cost.

The condition in a certain section became so serious, due to the above described causes, that a screening-crushing plant for the proper reduction of lump ore, and a screening plant for the removal of rock chunks from ore mixed with such material, were installed. Subsequently, when the open-pit conditions required it, this was followed by two further installations. The average capacity of each of these latter plants is about 20,000 tons per day of 20 operating hours. Both plants are heavily constructed units of steel and concrete, in which the ore movement is almost entirely by gravity, except for pan conveyors which convey the large chunks, some of which weigh several tons, from the screening grizzlies to the crushers, which reduce them down to pieces less than 5 in. in size. The operation of these plants has proven very successful, and has demonstrated that this is the practical and economical method of eliminating chunks in continuous open-pit operations.

\*Abstract of paper delivered before the American Iron and Steel Institute, October 28, 1927.

†Assistant to the president, United States Steel Corporation, New York, N. Y.

*Concentration of Sandy Iron Ores*—In the early exploration of the Missabe Range, sandy iron ores were encountered in considerable quantities in different parts of the range, especially on its western end in the area from Hibbing to Coleraine, in which a large proportion of the silica in the ore occurred in the form of fine sand. In 1907, after an exhaustive study and investigation, an experimental mill was erected, at which elaborate tests were made in treating this class of ore. As a result of these tests, a large five-unit concentrator was erected and placed in operation in 1910. The flow of ore through this mill is almost entirely by gravity. The essential machines in this plant are: 5 revolving bar grizzlies; 5 cylindrical wash trommels; 5 picking belts; ten 25-ft. and ten 18-ft. log washers; 15 settling tanks; and 100 tables. This plant developed a maximum capacity of about 30,000 tons per day of concentrates. The maximum annual production, however, made from it was 3,000,000 tons. A year ago, 6 bowl classifiers were installed in three of the units, to replace the 18-ft. log washers and the tables which had been used to recover the material finer than approximately 10-mesh. Crushers, and an elevator, were also installed in one unit so that the wash trommel oversize could be crushed and re-washed in one of the log washers, thus eliminating considerable silica in this lump material.

Beneficiation of these Missabe ores by washing gives the following general results:

|                            | Crude ore | Washed ore |
|----------------------------|-----------|------------|
| Per cent, Iron (Fe) .....  | 44.50     | 56.25      |
| Per cent, Phosphorus ..... | 0.045     | 0.055      |
| Per cent, Silica .....     | 32.00     | 14.00      |
| Per cent, Moisture .....   | 8.70      | 9.20       |

For many years, due to the high average iron content of the natural ores, it was not necessary or important to give the subject of beneficiation serious consideration. However, conditions have been changing materially within the past few years, necessitating, or at least making it advisable, to consider some method of treatment at the mine. Of late years, washing, screening, drying and other forms of treatment, as described above, are being successfully applied to certain of the hematite ores, the result being an improvement in the physical and chemical character of the product, thereby greatly reducing transportation and blast furnace reduction costs. Wherever it is commercially possible, impurities are being eliminated at the mines.

*Magnetic Iron Ores*—A realization of all of the above facts calls attention to the importance of the large magnetic iron ore deposits, many of which are located within comparatively short distances of blast furnace plants.

All magnetic iron ores are susceptible to beneficiation, and it is possible to increase the average iron



content of the ore (27 per cent to 35 per cent as mined) to various percentages from 60 per cent to 70 per cent, depending upon the fineness of the crushing and grinding. The finer the grinding, the higher the iron content in the concentrate, with the resultant elimination of practically all the gangue minerals. The degree of fineness to which ore can be reduced by dry grinding is limited, on account of the resultant amount of dust. A magnetic iron ore averaging 34 per cent iron and 0.08 per cent phosphorus, when ground wet to pass a 300-mesh sieve, has resulted in a concentrate analyzing over 70 per cent iron, less than 2 per cent silica, and less than 0.006 phosphorus. Dry concentration by milling to pass a 4-mesh screen can yield, from crude ore containing 30 per cent to 33 per cent of iron, concentrates containing from 62 per cent to 65 per cent of iron; and in an experimental way, by dry concentration, crude ores of 15.25 per cent iron have been concentrated to 63.85 per cent iron.

Most of the large deposits of magnetite in the United States and Canada require mining by underground methods; this is not considered, by operators, as a handicap, as continuous production is usually desirable, and very little difficulty is experienced in either the mining or milling operations during the winter months, whereas it would not be possible in many localities to operate open-pit and steam shovel work.

Both wet and dry concentration processes have been demonstrated, on a fairly large operating basis, at a number of magnetic iron ore properties. On account of the fineness of the highly concentrated ores, it is uneconomical as a rule to use them as such in blast furnaces. In recent years, the usual practice is to sinter or briquette these concentrates for blast furnace use, and this is being successfully and economically accomplished on a substantial tonnage basis.

From a study of the methods, as applied to the beneficiation of the magnetic ores in general, it appears that the problems have been pretty well solved and that types of standard machines have been developed that are satisfactory. This will be noted in the description of one of the fine grinding wet methods as follows:

**Mining**—Underground, shrinkage stopping, all ore hoisted and delivered directly from shaft to mill bins.

**Coarse Crushing**—The crushing of the run-of-mine material to 1-in. ring is done in three stages as follows:

Run-of-mine to 6 in. in a 36-in. by 48-in. jaw crusher, 6-in. to 2½-in. in a 24-in. by 36-in. jaw crusher, 2½-in. to 1-in. ring in a 48-in. horizontal disc crusher. The disc crusher operates in closed circuit with a screen. All crushing is done dry. No attempt is made to discard waste after any of the crushing stages. The finished product from the disc crusher passes directly to the main storage bins.

**Grinding and Concentrating**—The coarse grinding is done by two mills, both operating in closed circuit with an 8-mesh revolving screen, and having a capacity of 800 tons per 24 hr. About 50 per cent of the discharge from the mills will pass a 200-mesh screen.

Before passing to the fine-grinding circuit, the pulp from the coarse-grinding units passes in turn through a thickener, magnetic separators, and demagnetizers. The thickener and the magnetic separators both make waste products.

The fine grinding is done in two stages, in both of which 6-ft. by 48-in. mills in closed circuits are used

for the grinding. In the first stage, the pulp from the demagnetizers, noted above, passes to bowl classifiers, which are operated so as to overflow a product, 80 to 85 per cent of which will pass 20-mesh. The sands from the classifier pass to the 6-ft. by 48-in. mills, thence to magnetic separators making a waste product, and a middling product, which is elevated to a desliming thickener, the spigot product of which passes through a demagnetizer back to the bowl classifier. The overflow from the thickener is a waste product.

The overflow from the classifier of the first-stage fine-grinding, pass to magnetic separators placed in sets of two as usual, but with the first machine set to make a waste product. The second machine is given a special setting so that it makes a high-grade concentrate, and a middling product. This middling product is delivered to a classifier, the overflow of which returns to the separators, and the oversize to 6-ft. by 48-in. mills in closed circuit, the discharge from which returns to the classifier.

The high-grade concentrates from the separators in this circuit either pass directly to a desliming thickener and then to filters, or, in case a special high-grade low-phosphorus product is desired, they are passed over 150-mesh screens before being sent to the thickener. The oversize of the screen in this case is returned to the second stage of the fine-grinding circuit.

From the filters the concentrates pass to the briquette presses. The briquettes are hand piled on cast iron kiln cars with fire brick tops, and pushed through gas-fired kilns. The cars of burned briquettes, completely converted to hematite, are cooled and discharged to a skip hoist, to be delivered either to railway cars for shipment, or to the storage pile.

For dry concentration an operating unit for the milling of the ore after the hoist is as follows:

Direct from the headframe, the ore is passed over a rotary grizzly with 2½-in. openings. The oversize is sent to 10-in. by 72-in. jaw crushers for crushing down to 2½ in. and smaller.

Product passing 2½-in. grizzly goes to a vibrating screen which has ⅝-in. openings. The undersize, which contains the most moisture, is elevated to a tower drier, for moisture removal.

The feed to the concentrator is regulated by means of feed rolls, and conveyed to a belt conveyor, which discharges on to two vibrating screens having 1½-in. openings.

The resulting oversize goes to two 30-in. by 36-in. pulley-type magnetic separators, which throw out all the rock having not more than 4 per cent iron. This rock is stocked, and later reclaimed for ballast and concrete aggregate.

All the ore above 4 per cent iron is discharged from the magnetic separators to a set of heavy duty rolls, and crushed to 1½ in. and smaller, and then fed to a 30-in. belt conveyor, together with the material that has already passed through the screens of the above size.

The 1½-in. material is now passed over 12 vibrating screens having ¼-in. openings, the oversize from this operation goes to four 30-in. by 36-in. magnetic separators which eliminate the rock portion.

The separated ore is fed to two 54-in. by 24-in. rolls, from which it is returned to the above screen as a circulating feed. The product under ¼-in. is ready for final concentration where it passes over 100

vibrating screens having  $\frac{1}{8}$ -in. openings. The final size, everything under  $\frac{1}{8}$  in., goes to a battery of 16 30-in. by 30-in. magnetic drum separators, where the tailings are removed, and concentrated ore now containing  $62\frac{1}{2}$  metallic iron is ready for the sintering plant.

### Coal, Coke and By-Products

To select for acquisition coal acreages to provide for the future supply of the various types of coking coals has involved much vigorous field work, laboratory study and many experimental coking tests.

A laboratory for the specific purpose of studying coking coals was established at the time our first by-product coke ovens were built, to exclusively conduct such work as thorough testing of coal samples from diamond-drilling cores, or exploration samples, or mine samples, determining the theoretical by-product yields and probable coking qualities. These were followed by the actual coking of sizable tonnages, to note the coke quality, and the operating peculiarities of the coal in its passage through the carbonizing unit.

Many coal fields were thus tested, and before acreages were acquired, a complete history and operating knowledge of its product was pretty well predetermined.

A very certain and efficient method for the testing of the coking qualities and by-product yields of coal was developed in this laboratory, which method is now standard.

Much auxiliary work has been done, such as X-ray analysis of coal, observations of oxidation and weathering rate, factors influencing coking properties, and beneficiation studies, both in the laboratory and in the field, in testing of coals for improvement in their composition and quality, by cleaning by various methods.

In coal-mining operations it is the custom to sample working sections of all the mines. Any section of the mine found to be high in impurities is given prompt attention, and in a number of cases where sulphur or phosphorus proved high, the output has been either reduced, or loaded separately for the purposes for which it is considered satisfactory. At many coal mines domestic water supply is local; that is, it is obtained from springs or water-wells in the vicinity of the towns. If, after being analyzed, any source of water supply is found to be unfit for domestic use, the spring or well is destroyed or closed. Water is also analyzed for boiler purposes, and the air in the mines is given careful and frequent analyses.

A creditable investigation is the long study and money outlays made for building experimental plants for the treatment of acid mine waters, which problem has received the utmost consideration. In treating these mine waters, a by-product has been obtained in the form of a hydrated oxide of iron, though the low price of this by-product recovered, is too small to balance the cost of operations.

**Cleaning of Coal**—Comprehensive studies of the various coal cleaning methods have been conducted, and actual tests of coal from many fields have been made on the various equipment for mechanical cleaning, including the wet, dry and pneumatic processes. All principles for the reduction of impurities in coal are based upon differences in specific gravity between clean coal and impurities. The most successful plans for improving the quality of coal are based upon the flotation method of employing the difference in specific gravity. Of these, in large scale operations, water

flotation and air flotation are the two which have so far met with the greatest success. The advantages of each as compared with the other are as follows:

For Water Flotation—Ability to treat greater variation in size, in other words, to treat as small size coal as, and larger size coal than, air flotation.

Ability to treat coal in greater range of sizes in one operation (viz., in one jig or table), resulting in less screening required.

For Air Flotation—Avoidance of added expense on account of added moisture, either for transportation of the extra weight, or for evaporation in use.

An example of results obtained in the water flotation process, as conducted by a company washing large tonnages of coal, is shown below for the year 1926, where, in order to secure as low ash as possible in the coking coal, the bone or intermediate coal was also removed in the washing, and used for boiler purposes.

| Washer | RAW COAL |       |       |      | WASHED COAL |       |      |      |
|--------|----------|-------|-------|------|-------------|-------|------|------|
|        | Vol.     | F.C.  | Ash   | Sul. | Vol.        | F.C.  | Ash  | Sul. |
| No. 1  | 27.48    | 56.85 | 15.67 | 1.44 | 30.79       | 65.29 | 3.92 | 1.09 |
| No. 2  | 27.61    | 62.25 | 10.14 | 1.43 | 29.13       | 66.23 | 4.64 | 1.17 |
| No. 3  | 26.51    | 60.93 | 12.56 | 1.59 | 28.67       | 66.72 | 4.61 | 1.22 |
| No. 4  | 25.34    | 61.46 | 13.20 | 1.86 | 27.77       | 67.71 | 4.52 | 1.28 |

| Washer | BOILER COAL |       |       |      |
|--------|-------------|-------|-------|------|
|        | Vol.        | F.C.  | Ash   | Sul. |
| No. 1  | 27.64       | 59.31 | 13.05 | 1.62 |
| No. 2  | 26.00       | 59.80 | 14.20 | 2.00 |
| No. 3  | 26.05       | 60.85 | 13.10 | 2.03 |
| No. 4  | 25.12       | 61.20 | 13.68 | 2.20 |

|       | REFUSE                    |      |      |                          |       |      |
|-------|---------------------------|------|------|--------------------------|-------|------|
|       | Float at 1.37<br>Per cent | Ash  | Sul. | Sink at 1.37<br>Per cent | Ash   | Sul. |
| No. 1 | 3.9                       | 3.85 | 1.10 | 96.1                     | 70.62 | 2.14 |
| No. 2 | 4.2                       | 4.79 | 1.27 | 95.8                     | 61.83 | 4.67 |
| No. 3 | 4.9                       | 4.92 | 1.35 | 95.1                     | 63.33 | 4.08 |
| No. 4 | 4.7                       | 4.70 | 1.48 | 95.3                     | 56.00 | 5.24 |

|       | OUTPUT           |                     |             |                     |             |                |
|-------|------------------|---------------------|-------------|---------------------|-------------|----------------|
|       | Raw coal<br>tons | Washed<br>coal tons | Per<br>cent | Boiler<br>coal tons | Per<br>cent | Refuse<br>tons |
| No. 1 | 240,200          | 188,898             | 78.64       | 15,358              | 6.39        | 35,948         |
| No. 2 | 696,903          | 580,673             | 83.32       | 50,900              | 7.30        | 65,330         |
| No. 3 | 1,178,754        | 960,965             | 81.52       | 80,647              | 6.84        | 137,142        |
| No. 4 | 491,923          | 399,886             | 81.29       | 32,373              | 6.58        | 59,664         |

No. 1 washer efficiency 92.9% based on 3.66% inherent ash in coal  
No. 2 washer efficiency 90.2% based on 4.20% inherent ash in coal  
No. 3 washer efficiency 90.5% based on 4.20% inherent ash in coal  
No. 4 washer efficiency 92.4% based on 4.20% inherent ash in coal

No individual cleaning process can be claimed to be most suitable for all coals and all conditions. The choice of method will depend largely upon the efficiency of separation required; that is, whether a product of given quality will be satisfactory, or whether the maximum possible purity is demanded. Other factors that enter into the choice of any process are:

Maximum price that the consumer is willing to pay for the cleaned product.

Ability to secure and impound an abundant and cheap water supply.

Occurrence of impurities; i.e., whether freely associated or closely combined with the coal.

Distribution of impurities; i.e., whether uniformly distributed through all sizes, or greatest either in coarse or fine coal.

Possibility of a market or outlet for a middling product, thus enabling the cleaning plant to secure the cleanest possible coal, and the least wasteful reject.

It can be said that all of the treating processes will provide a more uniform product, by reducing the ash and sulphur content, and that a combination of the wet and dry systems would give better results on some coals than either all wet or all dry processes on the same coals. Therefore, each installation must be considered separately, and the best process selected to obtain the results desired, considering at the same time the added installation and operating costs.

**Utilization of Coal Mine Dumps**—Laboratory work, involving the utilization of waste materials which have resulted from mining operations, has recently developed a processing system to make a commercial and salable building article from the slaty material occurring in the burnt out refuse dumps, in certain favorable districts.

This material, consisting chiefly of calcined fire-clay, is crushed, sized and treated to produce roofing granules or coating materials, of several shades of red and brown. In the treatment process, spent pickling liquor from steel mill operations is used to a considerable extent. Thus by a happy combination, two waste materials are brought together to produce a high-grade, and an unusual and popular colored roofing element.

The patent application covering this conversion process is pending, and the outlook for the practical manufacture of this article is promising, thus by science two of the lesser by-products or waste materials are combined to become a merchantable commodity.

**Coking Properties of Coal**—The coking properties of coal have, we believe, received more intensive study than any other quality of this important commodity, and accordingly we will detail some interesting laboratory and field facts, developed after two years of work. This coking property of coal varies with different kinds of coal, it varies with coals from the same seam, and mined within comparatively close ranges, and it varies with different conditions arising in the actual coking operations. It is well known that, even in coals of practically the same analysis, the coking property is not necessarily even approximately the same, as is shown by the following actual operating and laboratory data, on two similar coals from different districts and different seams.

|                                       | COAL NO. 1<br>Per cent | COAL NO. 2<br>Per cent |
|---------------------------------------|------------------------|------------------------|
| Analysis (Proximate)                  |                        |                        |
| Volatile matter .....                 | 33.75                  | 33.05                  |
| Ash .....                             | 9.51                   | 9.12                   |
| Fixed carbon .....                    | 56.74                  | 57.83                  |
| Sulphur .....                         | 1.24                   | 1.25                   |
| Analysis (Ultimate)                   |                        |                        |
| Carbon .....                          | 78.38                  | 78.53                  |
| Hydrogen .....                        | 5.06                   | 5.10                   |
| Oxygen .....                          | 4.22                   | 4.50                   |
| Sulphur .....                         | 1.24                   | 1.25                   |
| Nitrogen .....                        | 1.38                   | 1.50                   |
| Chlorine .....                        | .17                    | .11                    |
| Phosphorus .....                      | .035                   | .015                   |
| Yields (Laboratory distillation test) |                        |                        |
| Coke .....                            | 73.4 per cent          | 73.6 per cent          |
| Tar .....                             | 9.4 gallons            | 9.6 gallons            |
| Ammonia (NH <sub>3</sub> ) .....      | 6.1 pounds             | 6.4 pounds             |
| Light oils .....                      | 3.7 gallons            | 3.7 gallons            |
| Gas .....                             | 12,200 cu. ft.         | 12,944 cu. ft.         |

From the above analyses, it is reasonable to assume that, by subjecting these two coals to exactly the same operating conditions, cokes of similar characteristics would be produced. That such an assumption is not borne out by actual results is shown by the following data obtained from the operation of a series of test ovens under the same normal plant conditions.

|                                                       | Coke from<br>Coal No. 1 | Coke from<br>Coal No. 2 |
|-------------------------------------------------------|-------------------------|-------------------------|
| Coking time .....                                     | 18.2 hours              | 18.2 hours              |
| Temperature of coke as pushed .....                   | 2075° F.                | 2081° F.                |
| Percentage of fines through 1" before screening ..... | 15.1                    | 8.0                     |
| Sieve test of furnace coke:                           |                         |                         |
| On 3", per cent .....                                 | 27.3                    | 25.0                    |
| Total on 2", per cent .....                           | 62.8                    | 75.0                    |
| Through 1", per cent .....                            | 2.5                     | 2.0                     |
| Strength .....                                        | 50.7                    | 75.0                    |
| Hardness .....                                        | 66.5                    | 76.7                    |
| Brittleness .....                                     | 69.8                    | 49.0                    |
| Fuel value .....                                      | 42.0                    | 91.0                    |
| Porosity, per cent .....                              | 47.0                    | 47.2                    |

The coke from Coal No. 2 produced an excellent grade of metallurgical fuel, while the coke from Coal No. 1 differed entirely in physical properties, and was of no value as a blast furnace coke. In the case of this coke, it was almost impossible to push it from the ovens without crushing the entire mass, yet the contraction of both coke masses was almost identical. It cannot be said that Coal No. 1 did not possess fusion properties, as the coal mass was thoroughly coked, yet the physical properties of the resultant coke show conclusively that these fusion properties were not similar.

The scope of extensive experimental studies, carried on at a large by-product coke plant dealing with the production of a metallurgical coke from high-volatile coal, and practical operating data gathered therefrom, show a decided improvement in the quality of the blast furnace coke has been obtained as evidenced by the physical properties of the coke and its reaction to blast furnace operations.

To produce improved quality of furnace coke, actual oven tests, under operating conditions, were required, and for approximately two years this work has been steadily carried forward. It was necessary to produce coke from different coal mixtures, employ different temperatures, different sizings, and different coking times, and to carefully correlate the coke plant operation with the reaction of the blast furnace, and establish a definite relation of the variables which produced either a good, or an unsatisfactory, blast furnace fuel.

That a better metallurgical fuel is being produced from the same raw material is definitely shown by the operation of the blast furnace. By suitable segregation of the coals and close temperature control, the production of this improved fuel could be continued, but it was not understood why coals of apparently the same composition should produce such different qualities of coke.

On reaching this stage of the study, determinations of the melting point, or plastic stage, of the coal were made. In this determination, the resistance of the coking mass to the flow of inert gases is measured under carefully standardized conditions. This, too, at first seemed unreliable, but by plotting these results and comparing them with the physical quality of the



coke, and the operation of the blast furnace, a definite relation was found to exist between them.

By adjusting the carbonizing temperatures of the ovens, it was found that the physical properties of the coke were immediately improved, and the blast furnaces on this coke responded correspondingly, indicating that the coke quality had been actually improved by a knowledge of one of the coking properties of a coal, its melting point.

It would now appear pretty sure, that the melting point, or plastic stage, of the coal is a very important factor in its coke-producing qualities, and probably the best index in selecting high-volatile coals for the ovens. Some coals begin to gasify at 420 deg. C., others at higher, and some at lower temperatures, and this melting point characteristic has now been found to be so important, as developed in conjunction with practice, that great care is exercised in mixing coals from various mines, so that only those of approximately the same melting point are used together. By segregating the coals in this manner, and by corresponding temperature control of the ovens during the coking period, an improved metallurgical coke product is obtained.

Further work is in progress to establish a definite relation expressible, if possible, in figures to show the influence of the melting or decomposition point of coal, and its resultant behavior on coke structure and blast furnace reaction.

*By-Product Coke Ovens*—By-product coke from the quality standpoint, in preference to beehive coke, for blast furnace and foundry use, is now so well recognized that there is no need to dwell upon this subject. The by-product coke oven operator, as heretofore stated, is continually endeavoring to further improve the quality of his coke by suitable technological studies of coals available, temperature control at the ovens, coking time, etc., with corresponding observation and attention, as to their effect on yields and quality of by-products.

Technological studies extended to the oven proper, or retort, have been principally in the direction of greater tonnage capacity, and this has been effected by gradual but sure development in the dimensions of the ovens, allowing more coal per charge, and also in the reduction in the coking time per charge, the net result being that a modern by-product coke oven can now produce about twice as much coke per 24 hr., as an oven, modern at that time, could produce per 24 hr. in 1909. Naturally, considering the heavy investment involved in a by-product oven, changes in dimensions have been conservatively made. The growth and development of the by-product coke industry in the United States has been very large, as is evidenced by the production of 5,607,899 net tons of by-product coke in 1907, while in 1926 the production was 44,376,586 net tons.

The success of the steel industry in increasing its by-product coking operations will no doubt gradually extend in other directions, and is today a significant educational factor that more coal should be processed for general public use. Approximately 85 per cent of all by-product coke made in this country today is being produced for metallurgical purposes.

A technical advance in operation of some by-product coke oven plants, particularly those supplying gas for municipal purposes, is the heating of the ovens with coal producer gas, thus conserving for the above purpose the entire production of the higher

heating value coke oven gas. Similar conservation of the high value gas from the ovens is accomplished at some European plants by employing blast furnace gas as the heating medium for the ovens.

Studies are being made of improved methods of recovering phenol constituents from the waste waters of coke plants in order to prevent the pollution of the streams into which they flow. Extraction plants have been built at considerable expense by the steel industry at various points, in endeavors to commercially overcome this condition; although successful in preventing entrance of the phenol into the streams, there are, as yet, no financial profits from the operation.

Desulphurization of coke oven gas is one of the technological studies not yet completed, which occupies an important position at the present time, particularly the effect it will have in rendering coke oven gas more suitable for the production of low-sulphur steel in open-hearth furnaces.

*Coke By-Products*—A certain amount of concern has been expressed from time to time as to the ability of the market to absorb the large quantities of by-products recovered in making by-product coke, to wit: tar, gas, ammonium sulphate and benzol. So far, all these by-products have been readily and profitably absorbed and we see no reason why this condition should not continue.

Benzol products have been removed from our coke oven gases since 1915, when war measures hastened the installation of plants, which had been earlier recommended.

The country's production of these aromatic hydrocarbons in 1926 totaled 132,843,665 gallons practically all recovered from its metallurgical coking units.

Improvement in quality and yield of by-products has been one of the slogans of producers for years, resulting in the production of, for instance, ammonium sulphate from coke ovens, equally as good and as greatly in demand as ammonium sulphate synthetically manufactured from atmospheric nitrogen. Improvements, also, in the refining of other by-products such as motor benzol, pure benzol, tuloul and solvent naphtha permit the production of high-grade noncorrosive and odorless products, thus removing the former principal objections to these commodities.

A close study is being given by the steel industry to the problem of tar and the most profitable disposition of this useful commodity by distillation or otherwise.

Continual study is also being made by the steel industry of the development and use of other by-products than those already referred to, which are recoverable from coke ovens: for instance, cyanides, alcohols, and the various by-products of tar distillation.

### Consulting Engineers Meet

At the meeting of the Chicago Association of Consulting Engineers held at the City Club on the evening of January 16, the annual election of officers was held and the present officers, Irving E. Brooke, president; Ernest V. Lippe, vice president, and Rollo E. Gilmore, secretary-treasurer, were re-elected for the ensuing year.

The membership consists of consulting engineers engaged in mechanical, electrical and sanitary engineering.

# The POWER PLANT

## *Developments in Steam Generation\**

A Review of the Progress Made in the Methods and Apparatus  
for Generating Steam—High Steam Pressures  
—Air Preheating and Fuels

By GEORGE T. LADD†

**D**URING the past quarter of a century, we have seen immense strides in all forms of industry. The steel industry, the industry closest to our hearts in Pittsburgh, has increased from an output of 10,188,329 tons in 1900 to 45,393,524 tons in 1925.

The output of the cement industry has increased from 14,311,407 barrels in 1899 to 164,057,000 in 1926.

The automobile industry has grown from nothing to an annual output of 4,000,000 cars during the life of all of us here.

The paper output has increased from 2,167,593 tons annually in 1899 to over 10,000,000 tons per year today.

The chemical industry with the manufacture of fertilizers, carborundum, aluminum, carbides, etc., is another new industry which has outgrown the clothes of a child and become a man within the memory of all of us here tonight.

The mining industry has grown from small isolated mines to a business requiring huge organizations with their own transportation systems and world wide affiliations. The mining of coal in our immediate territory has decreased, but this is only a temporary condition, as the demand for coal has not kept pace with the growth of other things on account of the increased economies in the use of coal of which I shall speak later. But the possible thermal economies to be made in the near future are small compared with those which have been made in the past few years—and the growth in demand for coal will once more keep pace with the growth in industry. This will again make it profitable to operate our coal mines.

Air transportation is an entirely new development and new plants are springing up for the manufacture of apparatus for this new field and its correlated industries.

Transportation by land and sea has grown by leaps and bounds to keep pace with ever growing demands.

The manufacture of rubber goods, textiles, drugs, glass and innumerable other major and minor products and their accessories has shown corresponding growth.

We have seen centralized heating, in our large cities, grow from small isolated plants in the basement of buildings to large plants similar to that of the Cecil Plant of the Allegheny County Steam Heating Company in our city.

\*Paper delivered before the Engineers' Society of Western Pennsylvania at the annual meeting, January 17, 1928.

†President of the Ladd Water Tube Boiler Company, Pittsburgh, Pa.

The incessant cry from every one of these industries has been power—more and more power.

The first response to this demand was the development of the steam turbine and we in Pittsburgh have closely been identified with this growth through the Westinghouse Company and George Westinghouse, a former member of this society. One of our past presidents, Mr. W. B. Spellmire, told you last year how the size of single steam turbines had grown from 5000 kw. in 1902 to 65,000 kw. in 1926 and to 208,000 kw. compound units in course of construction; how the pressure at which they operated had increased in the same period from 200 lb. to 1200 lb.; how the heat rate had decreased from 22,000 Btu. per kw.-h. in 1902 to 9600 Btu. per kw.-h. in 1926.

Single power houses generating 30,000 kw. in 1920, were mammoth affairs and today single plants of 200,000 kw. are in operation and plants of 1,000,000 kw. in the process of construction.

Twenty years ago, the development of the stoker, combined with the better economies of the turbine, enabled the old boiler plants to carry the increased station output, but as pressures rose and units grew larger, the old boiler houses could not meet the demand and the boiler maker began to study metallurgy and to turn his boiler shop into a machine shop to keep pace with modern industry. The author read a paper before this society in 1920 describing boilers of 2650 hp. each, which were then installed for a large industry in Detroit and told you how these were the largest boilers ever built and were then operating at 11,000 hp. each, and producing 330,000 lb. of steam per hour. To indicate the marvelous improvements that have occurred in the past few years, two of these boilers have been equipped with water wall furnaces increasing the total heating surface per boiler to 30,000 sq. ft. and each of these revamped boilers is now delivering continuously over 500,000 lb. of steam per hour and the latest one has produced over 600,000 lb. of steam per hour.

Air heaters were installed and the overall efficiency of these units producing the larger output is about one per cent greater than that of the original units.

In New York City, one year ago, three boilers were installed designed to deliver 325,000 lb. of steam each. They are actually producing 350,000 lb. of steam each and this output is only limited by the size of the fans. The fourth unit has just gone into operation and is producing 400,000 lb. of steam in the same space as one of the original units and studies now being made

on the fifth boiler indicate that a unit can be designed that will produce 750,000 lb. of steam in a similar space and it is not improbable that before 10 units are installed in this plant one will be designed to produce 1,000,000 lb. of steam in a similar space.

It is interesting to note the limiting feature is not securing proper materials, burning of the required amount of fuel, absorbing the heat in the boiler, providing for proper circulation or such things, important as these features are, but in providing for smokeless combustion. We used to think that smoky chimneys were a sign of prosperity but today the stacks of our large modern power stations are practically smokeless.

As explained before, pressures have increased from 250 lb. to 1400 lb. and in some foreign plants 3200 lb. is being experimented with. One of the properties of water is that as the pressure increases, steam bubbles, released in boiling, decrease in size, and, at 3200 lb. pressure, boiling, as we know it, is non-existent; the water passes into steam with no ebullition.

There are three steps in pressures for power houses in general use in this country.

- 1—160 lb. to 450 lb.
- 2—550 lb. to 800 lb.
- 3—1400 lb.

#### One Hundred and Sixty to Four Hundred and Fifty Pounds

There are many plants still in service at 160 lb. but these are small and relatively unimportant. There are a great many plants in operation at 250 lb. and these are fairly new. The upper limit of this type of plant is 450 lb. because above this pressure the steam, in passing through a turbine, loses its superheat, with an initial temperature of 725 deg., which is the limit today with materials now in general use. The steam condenses, and the condensed steam cuts the blades in the lower pressure section of the turbine. It then becomes necessary to pass the steam through a reheater to give it a certain amount of superheat and if we do this, it is more economical to go to 550 lb. to 800 lb.

#### Five Hundred and Fifty to Eight Hundred Pounds

These pressures are limited by the fact that the high pressure turbine and the low pressure turbine can be a single shaft with the generator. The steam passes into the high pressure turbine at 550 lb. to 800 lb. and 720 deg. F. total temperature and depending upon the design of the turbine is discharged at 400 lb. to 250 lb. and containing 15 deg. to 30 deg. F. superheat, is reheated to 720 deg. F. by being conducted back to a superheater in the same boiler setting as the primary superheater, or through a separate boiler especially designed for the purpose, or heated to approximately the temperature of the high pressure steam through a live steam reheater located at the turbine, or some combination of the above systems may be used. When the pressure is above 800 lb. to 900 lb. it is more economical to build the high pressure section and low pressure section in two separate units, each with its own generator.

#### Fourteen Hundred Pounds

At 1400 lb., the high pressure section is usually designed to operate at 3600 r.p.m. and the low pressure section at 1800 r.p.m. The high pressure section which is from  $\frac{1}{4}$  to  $\frac{1}{3}$  the capacity of the low pressure section, is the most efficient part of the unit and

for some recent plants under consideration is slightly less in cost per kw. The method of operation is as described for the preceding pressure, the steam passing through the high pressure turbine, hence to a reheater and back to the low pressure turbine. The turbine takes up very little space and is usually set near the boiler to simplify piping.

This pressure was chosen because it was felt it was not too high for metals which we knew about: valves and fittings could be constructed without too great a departure from adopted practices and the pressure was low enough so that the differences in density between water and steam was still great enough to produce good boiler circulation.

There are now three of these installations in operation and the troubles have been less than expected.

Two more installations will be made this year. The drums are made of forged steel. The rough drum is hammered out of an ingot, machined inside and out and the heads necked in so that heads are integral with the drum. The finished drums have an inside diameter of 40 in., a length of 20 to 40 ft. dependent upon the output of the boiler and the shell is from 3 in. to 5 in. thick depending upon the pressure and arrangement of tubes. Tubes are rolled in the ordinary manner, with two or more grooves  $\frac{1}{16}$  in. deep placed in the tube seat so that when the tube is rolled, the metal in the tube will be forced into the groove giving additional holding power. The large nozzles above 4 in. are fastened to the shell by stud bolts, the smaller ones rolled in and the other end of the tube rolled into a flange grooved in a manner similar to the tube seat in the drum.

Drums constructed in this manner have now been in operation for from one to two years and thus far have given no trouble.

Tubes are 4 in.,  $3\frac{1}{4}$  in., 3 in. and 2 in. in outside diameter. The smaller tubes have the advantage of dividing the water up into smaller sections and being thinner, give a better heat transfer. On the other hand, the larger tube gives more water storage and as the circulation is poorer at the higher pressure, due to the fact that the water and steam are more nearly at the same density, the tubes may last longer and the liability of rupture may not be as great. Research is now being made along these lines.

The Boiler Code Committee of the A.S.M.E. as well as the insurance companies have been co-operating with the manufacturers and users to give as large factors of safety as at lower pressures; in some cases, the factors of safety are greater. The process of forging a drum requires excess metal all of which is not removed in machining thus giving excess strength. Metals with a higher carbon content and, consequently, greater tensile strength, have been used for some of these drums and it is probable that alloy steels will be used in the near future. A committee composed of representatives of manufacturers, engineers and users of flanges and flanged fittings have been working on standards for steam pressures up to 3200 lb., and have already adopted and published a report giving a tentative standard up to 1350 lb. Several forms of satisfactory joints have been worked out and, in practice, less trouble is being experienced than at lower pressures. This is undoubtedly due to the very careful attention that is being paid to the manufacture and installation of the high pressure equipment.



Other recent improvements which have been concurrent with and necessary for the increased output of boilers are:

- a—Water conditioning.
- b—Pulverized coal.
- c—Water walls and screens for furnaces.
- d—Air preheaters.

#### Water Conditioning

If boiler water contains only 12 grains of foreign matter per gallon (this is considered very good boiler water) and the boiler is evaporating 500,000 lb. of steam per hour, the boiler will receive over 100 lb. of foreign matter per hour if none passes over with the steam. This would be over a ton every 24 hours so that it can be readily seen it becomes necessary to consider proper water treatment. It is usually necessary to distill the boiler feed water and as the make up in a modern station usually does not exceed 3 per cent, this does not present a serious problem. Pure water, however, is a wonderful absorber of oxygen. When the oxygen is carried into the boiler it usually attacks the metal of the drums or tubes and seems to do so more readily at higher temperatures. Therefore, it is necessary to remove the free oxygen from the feed water before introducing the same into the boiler.

#### Pulverized Coal

At the same meeting the author presented his previous paper on boilers, another paper was presented describing the application of pulverized coal to these boilers. This was one of the first, if not the first, large installation to use pulverized coal for firing boilers.

Since that time many other installations have been made, with many more in process of construction, and it is safe to say that no boiler installation goes in today without pulverized coal being considered. Stokers have been perfected and are still being installed on many jobs, but in developing a design to secure the maximum output of a large boiler in a small space, there is nothing to take the place of pulverized coal, and it would have been very difficult, if not impossible, to secure the large steam output previously described without the improvements that have been made in this method of burning coal.

#### Water Walls and Screens

The early large boiler installations had refractory furnaces. These had been used for years in spite of their known limitations and it was quickly found out that some other form of furnace construction would be necessary. Air cooled refractory walls were the next step. An air space, 9 to 12 in. wide, was left between the fire brick lining of the furnace and the outside wall. Air was circulated through this wall, heated, and the heated air admitted to the furnace. This was an improvement but it was soon found that better results could be obtained by lining the walls with water tubes and putting water tubes at the bottom of the furnace to keep the ash below the slagging temperature. These tubes are sometimes connected into the boiler circulation and sometimes have a circulation independent of the boiler. Such installations have now been in service long enough to demonstrate their usefulness for this work. The maintenance is less than with refractory walls and they add to the heat absorbing ability of the boiler. Last year, several steam generators were built and put into operation in

which the furnace was entirely lined with water walls to take the maximum advantage of this construction. The results obtained indicate that there will be many more of these installations.

#### Air Preheaters

Economizers have been used for a great many years to recover heat in the waste gases discharged to the stack and make for more efficient steam generation. The largest loss in the steam cycle has been and still is the heat absorbed by the condenser circulating water. In recent years, this has been decreased by stage bleeding, the condensed water is returned to the boiler through a series of reheaters, the water in these reheaters is raised in temperature by steam bled from successive stages of the turbine, so that the feed water is nearly at the temperature of the boiler water. This makes an economizer uneconomical and the air preheater has been designed to recover as much of this heat from waste gases as possible. The gases from the boiler pass through parallel passages in the air preheater, breaking up the streams into small lanes; the incoming air passes through other parallel lanes or across them in a direction counter current to the hot gases so that the temperature of the air may be raised as much as possible. The low limit is the dew point of the escaping gases which means that at the usual operating point of the boiler unit, the temperature of the escaping gases will be 300 deg. to 350 deg. F. The air is preheated to 450 deg. to 600 deg. F. and is used for taking the moisture out of the coal before grinding in case of pulverized coal and is introduced into the furnace to assist combustion with both stokers and pulverized coal. This has made possible overall efficiencies of 88 to 89 per cent with steam generator units operating at high ratings. When this is compared with 70 per cent efficiency, customary up to five and six years ago, it can be readily seen what has happened to our coal mines.

It is interesting to see an engineer working up plans for a new power station design. For pressure, he assumes the highest of each group heretofore described and works up propositions on each of the groups taking into consideration, water supply, cost of fuel, labor, money, load factor, etc., at the immediate time as well as the probable trend over a number of years to come. After this is done, he makes an intensive study of each group to see if each piece of apparatus is going to pay for itself; perhaps the last one or one and one-half per cent efficiency will not earn enough to pay for its keep; perhaps some one piece of apparatus can be set on a different floor or in some other part of the station, thereby saving a man on each shift; perhaps the plant is to be located where land is cheap and natural foundations available and a low spread out plant is the most economical; perhaps the plant is to be located in the city or where expensive piling must be used and a tall plant occupying little ground area is the most economical.

All these questions are given careful consideration by the engineer today and studies of future power houses are begun two or three years before they are needed, in order to give proper weight to the various features. It is interesting to note that most of the hydro-electric systems have built or are building steam plants to supplement their water powers and at the present time many of these corporations are installing steam plants that will produce electric cur-

rent at a less cost than they can secure it from extensions to their hydro plants.

With such things being done today, it would be a bold man who would make any predictions as to probable developments even within the next few years.

The high pressure units make possible the bringing up to date of the present 250-lb. to 400-lb. plants by giving increased capacity and increase in overall efficiency. As the exhaust steam turbine bridged the transition from engines to turbines so the superimposing of high pressure units will bridge the transition of low pressure power houses to high pressure ones. When we consider the industrial plants using steam for process work, the high pressure turbine offers still greater possibilities. By raising the steam pressure to 800 lb. or 1400 lb. and using the turbine as a reducing valve, electricity can be put at the switchboard for 1/3 of a pound of coal per kw. and the steam is then available for its usual work.

#### Low Temperature Distillation

The fact that coal heated to about 1000 deg. F. gives up most of its volatile gases from which benzol, gas, tar and hundreds of other by-products may be obtained and leaves a coke, has been known for many years and millions of dollars have been spent in experimental plants to recover these by-products before using the coal for fuel. The coke produced is not a metallurgical coke, and the uses to which it could be put have had a limited application.

A system, in which the coal is pulverized before being heated, and the resultant coke is ready to fire under boilers in a pulverized form has been in operation for over a year in Milwaukee and has proceeded far enough to warrant the statement it will succeed.

Another system in which the resultant coke offers a successful domestic fuel has been in commercial operation at Essen, Germany, since 1924 and a similar plant is now being erected at New Brunswick, N. J. For steel plant work, it is suggested such a system would replace the present producer plants, the resultant coke would be used to make water gas and the gases obtained from these processes would be used to mix with blast furnace gas and coke oven gas to produce a gas that would give maximum results in the plant. This business is in its infancy and has proceeded far enough to indicate its rapid growth from now on.

#### Dry Quenching of Coke

The usual way of quenching metallurgical coke has been by water.

By this method:

The sensible heat in the coke is lost.

The water splits the coke, thus lessening the amount of large sized material.

The coke contains a large percentage of moisture.

In Europe, there are 12 installations and in the United States there is one installation in which the coke is introduced into a furnace, a fan circulates an inert gas through the coke and over a waste heat boiler. The coke is reduced to about 350 deg. F. and from 650 to 900 lb. of saturated steam is produced per ton of coke dry quenched.

The coke is much superior to the water quenched coke and the heat of the coke is put to a useful purpose.

The operation is automatic thus releasing men for other work.

Such arrangements can be applied to other purposes such as recovering the heat from cement clinkers. In fact, the recovery of waste heat from oil stills, zinc, copper, steel and glass furnaces and all industrial operations is receiving increasing attention and the installations that have been made are saving thousands of tons of coal annually.

The rapid increase in research supplemented by manufacturers who are putting these discoveries into practice makes the future most interesting to contemplate and we can consider ourselves fortunate that we are able, not only to contemplate, but to take part in this development.

### Steel Treaters to Meet at Montreal

The semi-annual meeting of the American Society for Steel Treating will be held at the Mount Royal Hotel, Montreal, on Thursday and Friday, February 16 and 17.

This meeting will provide opportunity of a meeting of the board of directors and numerous committees of the society as well as five sessions of technical papers, plant inspections and a number of winter sport activities.

A very large attendance is expected from the states as reservations at the hotel are already quite heavy.

The schedule of events is as follows:

#### WEDNESDAY, FEBRUARY 15

##### Afternoon

- 6:00—Early Birds' Dinner. Special tables in Main Dining Room.
- 7:30—Option of tobogganning or theater party. Special cards of admission for the Toboggan Club will be sold at the Early Birds' Dinner.

#### THURSDAY, FEBRUARY 16

##### Morning

- 9:30—Technical Session. Piazza Room, Ninth Floor.

##### Afternoon

- 2:00—Technical Session. Piazza Room, Ninth Floor.
- 6:30—Dinner. Special tables in Main Dining Room. Technical session following. Piazza Room, Ninth Floor.

#### FRIDAY, FEBRUARY 17

##### Morning

- 9:30—Technical session. Piazza Room, Ninth Floor.

##### Afternoon

- 1:30—Choice of Plant Inspections:
  - 1—Canadian Steel Foundries, Longe Pointe Plant, manufacturing locomotive frames, railroad castings and hydro-electric castings; and McVickers, Ltd., the largest Canadian producers of aeroplanes.
  - 2—Dominion Engineering Works, Ltd., and Dominion Iron Works, Ltd., manufacturing largest paper machinery on this continent; also oil stills, tank work and some heavy construction work.
- 6:30—Dinner. Special tables in Main Dining Room. Technical session following. Piazza Room, Ninth Floor.

# Power and Heating Needs in Power Plants\*

Of Ever Increasing Importance Is the Question as to Whether It Is More Economical to Purchase Power or to Generate It in the Plant—This Question Is Discussed by the Author

By C. L. HUBBARD

THE relative advantages of generating power in the privately operated plant, as against purchasing current from a central station, are a matter of vital importance to the operating engineer, and one which should be considered from all angles.

Although the final decision in any given case is in the hands of the management, it rests largely with the operating engineer to produce the actual facts upon which such a decision should be made. It is not expected in this article to bring out anything especially new, but to separate from the large amount of data and suggestions offered by others those matters which seem of the greatest importance, and upon which the question seems to hinge.

I may say at the start that local conditions vary widely, and that while in one case it may be decidedly to the advantage of the owners to generate their own power throughout the year, another plant may call for the opposite procedure and show much better results with purchased power. Again, a third case may give the greatest operating economy by taking a middle course—that is, generating a certain proportion of the power required and purchasing the remainder as needed from a central station.

In the past it has seemed to be the policy of the promoters of both the isolated and the central plant to claim superiority in all cases, but recent discussions appear to take the more rational view of divided service, according to local requirements, which may mean all generated power, all purchased power, or a combination of the two.

The latter is the logical position to take, and one which will give the operating engineer the greatest influence with the management of his plant. The central station may be loth to admit this; but when the facts in any given case are properly presented there can be but little doubt as to the best method to pursue.

The governing factor in nearly every case is the proportion of the heat contained in the fuel burned under the boilers which can be utilized in doing necessary work. In the highest-class and most-efficient central stations from 15 per cent to 20 per cent of this heat is utilized in the production of power, while the remaining 80 or 85 per cent is wasted through radiation and the condensing water. In the ordinary industrial plant of 500 kw. or less, about 5.6 per cent of the heat of the fuel appears in the form of power at the switchboard when exhausting outboard, and about 8 per cent when operating condensing.

If all the exhaust from the engine can be utilized while the plant is running non-condensing, about 65 per cent of the heat in the fuel can be made use of, as against 20 per cent in the most highly developed central stations employing steam for the generation of power. Of course, kw. per lb. of fuel do not represent the ultimate basis of comparison between the two

types of plants, as numerous other factors enter into the actual cost per kw. However, the foregoing figures show that the central station cannot compete with the private plant where all, or a large proportion, of the exhaust can be utilized for heating and process work. While the overhead charges per kw. may be less in the central station, due to its larger size, this advantage is soon offset by the salvaging of the exhaust in the smaller plant.

Although it is important to raise the operating efficiency of the private plant to the highest practical point by skilful firing and the use of well-made and properly adjusted equipment adapted to its work, the most important results will be obtained by means of such arrangements and methods of operation as will utilize the greatest amount of exhaust steam on a yearly basis.

The difficulty in most cases is in securing a proper balance between the power and heating requirements. For example, during the colder months there may not be sufficient exhaust steam for all heating and process work, so it may be found necessary to draw on the boilers for live steam at a reduced pressure; on the other hand, during the summer no steam will probably be required for heating, and a large part of the exhaust may necessarily be discharged outboard. Between these extremes will be a variety of conditions depending upon varying outside temperatures. In other cases there may be a wide variation in the available exhaust and the heating requirements during different parts of the day, regardless of the season of the year.

The greater part of this article will be devoted to a brief review of the different methods that have been suggested, or tried out, for improving the heat balance, with a view to increasing the utilization of the exhaust, or of extracting power from live steam in the process of reducing its pressure.

Before doing this there are two or three points which I will touch upon in a general way, as they are made a good deal of in connection with the matter under consideration, and have perhaps assumed greater importance as regards their influence on the private plant than circumstances actually warrant. The first of these is the matter of hydraulic power, and the second is the superpower project.

In making a comparison between the cost of power in private and central plants I have considered only those operated by steam. It is often stated that one of the greatest competitors of the isolated plant is the hydraulic development, the idea being advanced that power can be produced in this way at a much less cost than by steam.

Taken as a whole, hydraulic power is not cheap power; for while the actual cost of production is small after the plant is once installed, the development is expensive and the overhead charges correspondingly large. For this reason electric energy is now being produced in many steam plants at a lower cost per

\*National Engineer.



kw.-h. than in many hydro-electric stations. Only a comparatively few of the latter in U.S.A. can successfully compete in low cost of generation with the large, modern, well-located steam plant. This, at first thought, may seem absurd, since steam plants require fuel and water-power plants do not; but there are many items entering into the cost of power besides fuel, and these are reflected in the hydro-electric development as noted above.

Another point that has been made much of in this connection is the location of large steam generating plants at the coal mines, and so doing away with the transportation of fuel. This seems very attractive when looked at from a single angle, as might naturally be done by a layman. The engineer knows that the economical generation of steam power requires large quantities of condensing water; and that unless this is available close to the point where it is to be used, the increase in fuel consumption may, in many cases, more than offset any gain by the elimination of freight charges in the transportation of coal. Condensing stations having a fuel efficiency of 1.5 lb. to 2.5 lb. of coal per kw.-h. require from 500 to 700 tons of cooling water for every ton of coal burned under the boilers.

There are a number of mine-mouth stations of comparatively small size that make use of cooling towers, so that only the make-up water is required after the plant is once in operation. In cases of this kind the temperature of the cooling water is somewhat higher, which, of course, results in a loss of efficiency. In general, every 15 deg. rise in the temperature of the cooling water increases the coal consumption per kw.-h. about 5 per cent.

Again, the transmission of the electrical energy to the market adds another item which in itself alone soon exceeds any saving in fuel transportation. Of course, there are isolated cases where conditions are right for the location of large generating plants in the coal-fields, but not on the scale proposed in many of the super-power schemes.

The general conclusion is that coal can be hauled cheaper than electrical energy can be transmitted, if the distance is much in excess of 50 miles. This illustration is given simply to show that offhand statements regarding the advantages of super-power systems should be carefully analyzed before one plans to abandon the isolated plant.

Suppose, however, in spite of these handicaps, there should be a constant enlarging of the super-power idea upon a national scale. This would not materially affect the status of the privately owned-plant with reference to the central station. The isolated plant is concerned with super-power development only through the latter's representative, the local central station, with which it has to contend at the present time. The fact of tying one central station with another into a system with other and more distant stations should not increase local competition to any appreciable degree, for it is not likely that any advantage gained would appear in reduced rates to customers for some time to come.

Let us now take up some of the more common methods that have been employed for improving the heat-balance in combined power-and-heating plants. Where a considerable proportion of the exhaust can be utilized, or where the heating requirements are large compared with the power requirements, it is customary to consider the former as the regular load, and power as a by-product—that is, if a certain amount of low-

pressure steam is required for heating and process work, high-pressure steam can be generated with a very small increase in fuel, and the pressure reduced by passing the steam through an engine or turbine with a comparatively small expenditure of heat, thus producing power at a very low cost.

To generate 1 lb. of steam at 5 lb. pressure from a feed-water temperature of 50 deg. F. requires 1,138 Btu., and to generate the same quantity at 120 lb. pressure requires 1,174 Btu., or  $1,174 - 1,138 = 36$  Btu. more.

Suppose an industrial plant requires 3,000 lb. of low-pressure steam per hour for heating and process work. If, instead of generating it at 5 lb. pressure, the boiler pressure be raised to 120 lb., it will require  $3,000 \times 36 = 108,000$  Btu. more. But in this case we may pass the steam through an engine, having a water rate of, say, 35 lb. per kw.-h., and produce  $3,000 \div 35 = 86$  kw. of electric energy per hour, and have left in the exhaust the heat equivalent of at least  $0.9 \times 3,000 = 2,700$  lb. of low-pressure steam for heating work. In order to have the full 3,000 lb. required, it will be necessary to generate  $3,000 \div 0.9 = 3,333$  lb. of high-pressure steam, which will produce  $3,333 \div 35 = 95$  kw.-hs. if passed through an engine or turbine instead of a reducing valve. In this case the additional heat required over the generation of 3,000 lb. of steam at 5 lb. pressure is  $108,000 + (333 \times 1,174) = 498,942$  Btu. per hour. With a boiler efficiency of 70 per cent, and fuel having a heat value of 13,500 Btu. per lb., this will require  $498,942 \div (13,500 \times 0.7) = 53$  lb. of coal, or  $53 \div 95 = 0.56$  lb. per kw.-h. for the power generated, against 1.5 lb. to 2 lb. in the central station.

Thus power can be generated with less fuel in some private plants than in the central station. How much this saving will be, or whether there will be any, depends upon the average relation between the power and heating requirements throughout the year. This varies widely in plants of different kinds, from those in which all the exhaust may be utilized to those in which its only use is of warming the buildings during a very short and mild winter and for heating the feed-water. Between these extremes are all sorts of conditions, so that each case must be studied independently.

Woolen and worsted mills, paper mills, etc., require large quantities of steam for process work and drying, while plants engaged in the manufacture of cotton goods require but little, except for warming the buildings during the winter. Hotels use large quantities of hot water throughout the year, in addition to heating for a portion of the time, while office buildings utilize but little exhaust steam except for warming the building, unless they contain lunch rooms or restaurants on a large scale.

In process work of various kinds, the temperature and pressure of the steam vary, so that it is often impossible to use exhaust steam at the usual pressures of 2 to 5 lb. gauge. Again, it is difficult to remove all traces of oil from the exhaust of engines—a condition that is absolutely necessary when the exhaust is used for certain manufacturing processes.

The back-pressure turbine takes care of work of this kind, as it will work against back pressures of 100 lb. or more, utilizing as much of the exhaust (which is free from oil) as possible, and expanding the remainder in a second turbine or engine down to the pressure used in heating the buildings, or disposing of it in a condenser during the non-heating season.

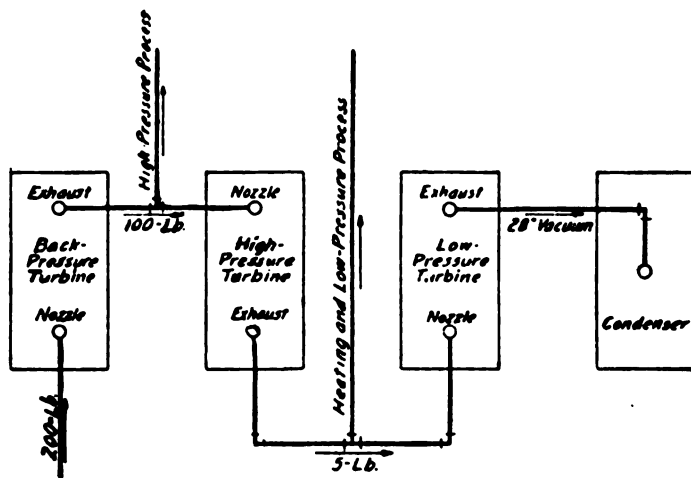


FIG. 1.

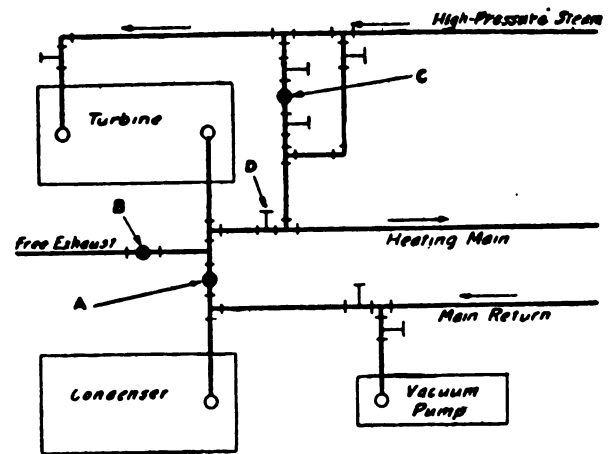


FIG. 2.

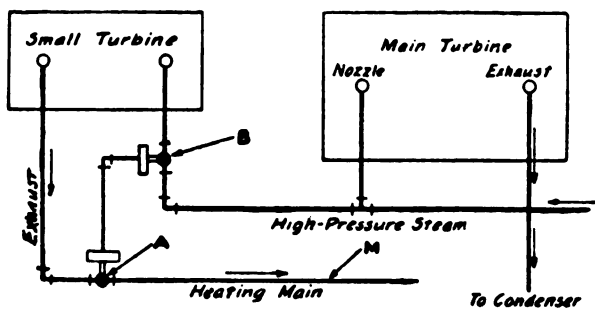


FIG. 3.

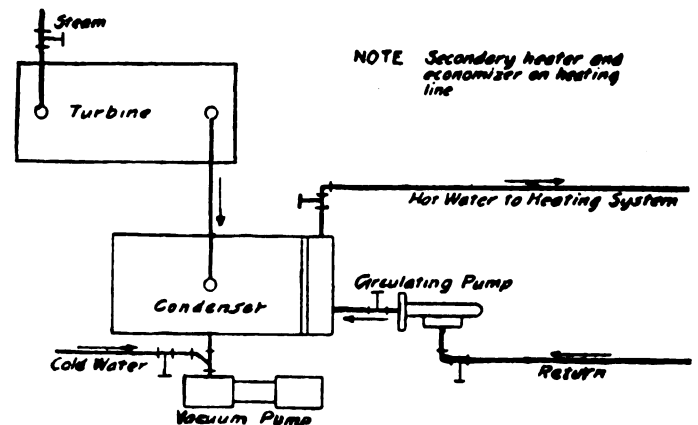


FIG. 4.

By combining a back-pressure turbine, taking steam at high initial pressure, with an ordinary non-condensing turbine and a low-pressure—or exhaust—turbine, as in Fig. 1, we have an opportunity to withdraw medium-pressure steam for special processes and low-pressure steam for heating and ordinary process work. In this case all steam used for these two purposes first will have done work in the generation of power. This same arrangement is utilized in a more compact form in the bleeder—or extraction—turbine, where steam is bled from different stages of the machine according to the pressure required. In a plant already installed it may be best to supplement the present equipment with a back-pressure turbine or an exhaust machine or both, according to the requirements, while in a new plant it would be simpler and more economical to use a bleeder turbine.

The bleeder turbine is especially adapted to cases where the relation between the power and heating requirements varies from time to time throughout the year. This type of turbine may be considered as a high-pressure machine that can operate condensing, non-condensing, or partly condensing and partly non-condensing at the same time. With this machine just enough steam may be extracted at low pressure (usually about 5 lb. gauge) to supply the variable heating demands, while the remainder passes on through the low-pressure stages of the turbine to the condenser. The effect is that of using a non-condensing and a condensing turbine together, and varying the load on the former so as to produce just the amount of exhaust

steam required for heating purposes at all times, and making up the remainder of the power load by means of the condensing turbine.

Not only does the bleeder turbine combine the two units in a single machine, but the distribution of the load between the two takes place automatically according to the amount of steam extracted. During the winter, when low-pressure steam is required for heating, the load on the non-condensing section is at a maximum; and in the summer, when but little is needed, the turbine acts nearly as a condensing machine. The steam supplied at the throttle for a given power output is, of course, greater when steam is being bled, because it is not so economical to operate a portion of the machine non-condensing.

For example, a 500-kw. turbo-generator requires approximately 9,000 lb. of steam per hour at the throttle when no steam is being bled and the entire machine is operating condensing. This is at the rate of 18 lb. of steam per kw.-h. When extracting 10,000 lb. of steam per hour at 2 lb. pressure for heating, the steam supplied at the throttle, while generating the same power, rises to 15,000 lb., or at the rate of 30 lb. per kw.-h.

Considering steam for heating as the main load on the boilers, and power a by-product, the cost of power when extracting 10,000 lb. of low-pressure steam is based on 100 lb. of steam per kw.-h. The same curve shows the cost of power to be 5.2 lb. of steam per kw.-h. when 16,000 lb. is being bled from the turbine.

With this type of machine no exhaust is ever discharged outboard and no live steam is ever used for heating purposes, both of which are in the line of maximum efficiency, and for this reason the bleeder turbine should usually be investigated in all cases where there is considerable variation between the exhaust produced from normal power requirements and the steam required for heating. This applies especially to new plants, and also to a considerable extent to the remodeling of existing plants.

An arrangement that may be applied to cases where an engine or turbine and a condenser are already installed is shown in Fig. 2. The results obtained in this way approximate those of the bleeder turbine to a certain extent, but do not ordinarily give as high an efficiency. This plan is readily applied to cases where the prime mover is already installed, and it should be given careful consideration.

In Fig. 2, A is a relief valve set to open at 5 lb. absolute pressure (20 in. of vacuum), and B is a back-pressure valve set to open at 1 lb. gauge pressure. In operation, valve A and pressure-reducing valve C automatically maintain a uniform pressure of 5 lb. absolute in the heating system, this also being the back pressure on the engine. In case all the steam cannot be condensed in the radiators, the pressure will rise slightly, causing valve A to open and allow the surplus to pass into the condenser, in which a vacuum of 26 in. to 28 in. is normally carried. This scheme is applicable only to the return-line vacuum system of steam heating, and the condenser takes the place of the usual vacuum pump, the main return from the heating system being connected as shown in Fig. 2.

Usually, however, the vacuum pump is provided, and the connections so made that the system may be operated either way. During the summer the heating system is cut out by closing valve D, and the engine operated full condensing. In extremely cold weather the back pressure can be raised temporarily at a loss of engine efficiency, but this is not a serious matter, as no exhaust will be wasted. This same arrangement is easily applied to a system of forced hot-water heating by connecting the steam supply and return pipes with a tubular heater instead of the direct steam system shown in Fig. 2.

An arrangement adapted to plants where low-pressure steam is required in varying and rather moderate amounts for heating or process work is shown in Fig. 3. In this case power for the main plant is generated by a condensing unit; then, instead of obtaining the required low-pressure steam by means of a reducing valve which does no useful work, a non-condensing turbine is employed, arranged to supply the required amount of exhaust automatically through slight pressure changes in the heating main. Referring to the drawing, valve A, which is similar in its principle of operation to a pump governor, acts on throttle valve B according to the steam demands on pipe-line M. The power generated by the smaller turbine is transmitted to the switchboard and relieves the main generator of a like amount.

In plants where there is a large and fairly constant demand for low-pressure steam for feed-water heating and process work throughout the year, a non-condensing engine or turbine may be used to furnish approximately this amount of exhaust. In addition, there may be another unit of sufficient capacity to furnish the remainder of the power required; this being of an economical type and arranged to run non-condensing

through the winter, thus furnishing exhaust for heating, and condensing during the summer.

Another plan is to generate power by non-condensing engines or turbines throughout the year to the point where all the exhaust can be utilized for heating purposes, and purchase the remainder as needed on a metered basis from a central station. Combinations can sometimes be made between a number of plants located fairly close together for an interchange of steam and power which will tend to equalize the heat balance and so greatly reduce the cost of power for the group.

Very satisfactory results have been obtained in other cases by pumping the cooling water from the condenser through the radiators employed for heating the buildings, as indicated in Fig. 4. In average cases a vacuum of 24 in. to 26 in. can be obtained from the cooling effect of this arrangement throughout the fall and spring, when the outside temperature is fairly mild, by admitting cold water into the suction of the vacuum pump, giving it the effect of a jet condenser. As the weather grows colder and a higher water temperature is required, the vacuum is reduced by cutting down the injection water at the vacuum pump, until it is finally cut off entirely. When a still higher radiator temperature is required for the coldest weather, a secondary heater supplied with exhaust steam from the auxiliaries is brought into service, and finally the water is by-passed through an economizer in the smoke connections.

The various schemes mentioned for improving the heat balance are all along practical lines, although not applicable to every case, and are given as suggestions for further study in connection with special problems.

### Power Show a Success

The Sixth National Exposition of Power and Mechanical Engineering exceeded the hopes of the exhibitors and managers for its success. As a record of progress, in diversity and interest of exhibits, and in attendance, this exhibition far outstripped preceding events. During the week of December 5-10, the Grand Central Palace received over 110,000 visitors, who enjoyed the novelties revealed by 530 manufacturers, arranged on four floors of the building. Twenty-five thousand engineers and industrial executives who were potential purchasers of mechanical equipment, registered their attendance.

In anything short of a book, it is impossible to give more than a general impression of the advances in the generation and utilization of power that were placed on record at the exposition. The products of the exhibitors were actually listed under 1,000 different heads, and to properly value the interesting showings and to point out the progress made is well-nigh an impossible task.

Some outstanding groups of exhibits were well worth enumerating, although figures in themselves do not give an accurate picture of the interesting features of the show. There were 450 exhibits dealing with the generation of heat and power and its distribution and utilization. Heating and ventilating and refrigeration equipment for industries, factories, offices and all other types of buildings were represented by 225 exhibitors. There were 100 showings of instruments for recording and controlling temperature, pressure, volume, rate of flow and, in fact, all the variables which must be controlled in modern industry.

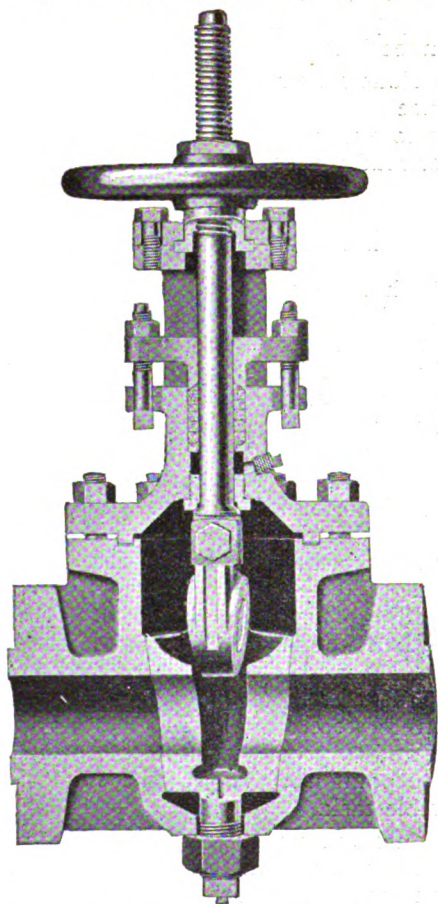


## WITH THE EQUIPMENT MANUFACTURERS

### Wellman Supertest Gate and Globe Valves

Users of valves for high pressures and high temperature purposes will be interested in an entirely new type of valve which has been developed by The Wellman-Seaver-Morgan Company, engineers and manufacturers of Cleveland, Ohio, which is being marketed under the trade-name of "Wellman Supertest Valve."

In previous types it has been customary to provide valve seats in the form of externally threaded rings which are screwed into internally threaded sockets in the valve body; experience has shown that high pressures and high temperatures cause such seat rings to creep away from the abutting surfaces, and this is followed by corrosion, wire drawing, and consequent leakage through the threads of the back fences of the seat rings and sockets. In the Wellman Supertest Valve construction the valve seats are an integral part of a slightly tapered removable valve-cage, and



the valve cage itself has an external take-up adjustment to compensate for the expansion or contraction and prevent leakage between the walls of the cage and the main valve body.

Another unique feature is the fact that the valve cage may be utilized to shut off the flow through the valve while repairs or adjustments are being made, entirely eliminating the necessity of taking the entire

valve body out of the line. When it is desired to make repairs it is only necessary to rotate the cage a quarter turn to prevent the passage of fluid through the valve and permit the removal of the internal parts if desired. When the valve has been repaired, the valve cage is restored to its normal position.

The valve cage has guides corresponding with slots in the wedge-type gate, which control the path of travel of the gate and prevent rubbing of the surfaces of the gate and seat. The valve seats are flat permitting the closing of the valve under high pressures, at the same time allowing the valve to be easily opened. The gate faces are removable and may be replaced when worn, or adjusted when desired. A solid wedge can be furnished on request. The whole arrangement is such that the valve surfaces are released from the seat at the slightest movement of the valve stem on account of the wedge shape with its center guides which practically eliminates any sliding action. This avoids both wear and the wedging of the valve faces against the valve seats which would make difficult the opening of the valve.

These valves conform to dimensions which have been approved by the American Society of Mechanical Engineers Standards Committee for steel pipe flanges and flanged fittings, while the materials conform to the requirements of the American Society for Testing Materials. The one piece valve bodies, as well as the bonnets, are of forged steel. The cages, gates, gate bolts, stems, bushings, and gate seats are of stainless steel.

These valves are made in both the gate and globe types to meet the requirements of the highest temperatures and pressures used in modern steam plants, oil refineries, pipe lines, and in hydraulic, air and gas lines in the various process industries. The gate valves are of the rising stem type and have a straightway flow, there being no angles at the valve seats; the packing boxes are elevated and have long depth of packing with a large air chamber below the packing. The body and cover flanges have tongue and groove joints for soft steel corrugated gaskets. The gate valves are made in 1-in., 1½-in., 2-in., 3-in., 4-in. and 6-in. sizes, and we are advised larger sizes up to 24 in. can be supplied. The globe valves have forged steel bodies and bonnets with either inside screw, or outside screw and yoke, and the removable cage construction allows full capacity openings through the valve. They are made in ¾-in., 1-in., 1½-in., 2-in. and 3-in. sizes.

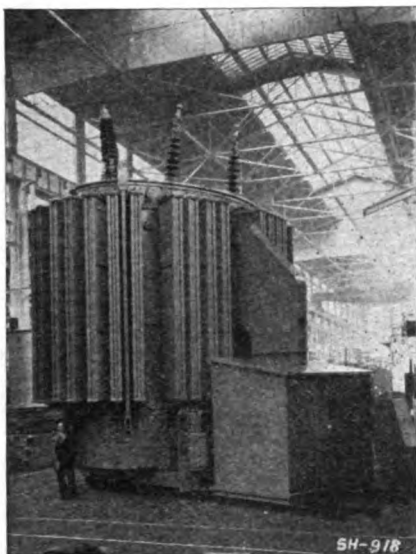
These valves will be shown at the Chicago Power Show in February, 1928, and a new bulletin descriptive of the entire line will be available about February 1, for those who are interested.

### Exceptionally Large Transformer

Capable of furnishing sufficient electrical power to light, heat, and transport, a city of half a million people, seven transformers, the largest in the world, have just been completed at the Sharon Works of



the Westinghouse Electric & Mfg. Company. The gigantic electrical mastodons are for use near Philadelphia in connection with the new Conowingo Dam project of the Philadelphia Electric Company.



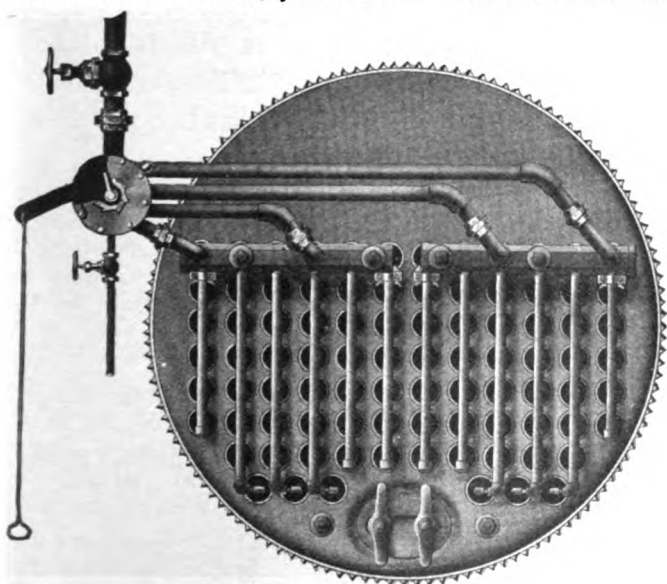
The transformers are gigantic in size and appearance. Each stands over 31 ft. in height, weighs over 200 tons and has a voltage of 220,000 v. which is the highest in actual use in electric power transmission. Each year \$12,000,000 worth of electricity will pass through the seven transformers.

Several cars will be required to ship each transformer. To carry the heaviest part, railroad officials found it necessary to build a special flat car, having 12 wheels and a carrying capacity of 220,000 lb.

The seven transformers require 20 car loads of oil for cooling and insulation.

### New Soot Blower

"National" Soot Blowers, made by the National Flue Cleaner Company of Groveville, N. J., are described in a bulletin, just issued. These blowers are

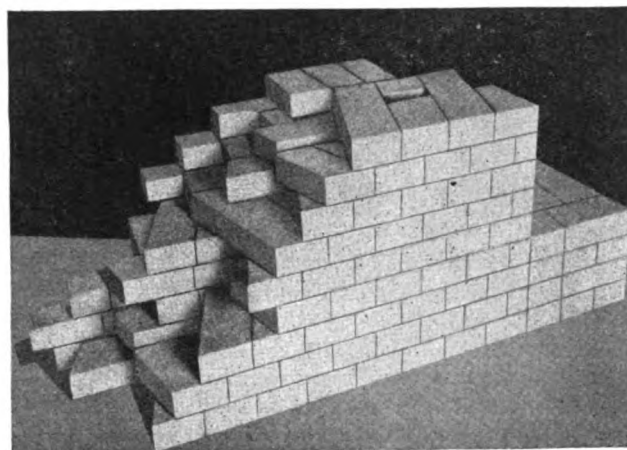


designed only for use with horizontal return tubular and Scotch marine boilers. Unlike other types, they employ a separate nozzle, in a fixed position, for each

boiler tube. This makes it impossible for any tube to escape the scouring action of the steam jet. The blower is located in the front of the boiler and is operated from the floor level, the tubes being cleaned in four sections, in turn. Where the up-take is in the back of the boiler, and the hot gases make a third pass over the top of the boiler shell, batteries of nozzles are also provided for cleaning the shell. These soot blowers can be operated with either steam or compressed air without interfering with the steaming of the boiler. Since a one-fifth inch coating of soot is equivalent as a heat insulator to a 1-in. layer of asbestos, a substantial economy in fuel invariably results from frequent soot blowing.

### Biasbrix

One of the most difficult problems of fire brick construction, in the opinion of a great many engineers, is the difficulty of making brick stay put under the stress and strain of actual working conditions. There is always the tendency for walls to loosen up and joints to open, resulting in heat losses, slag penetration and eventual disintegration. This problem of a stronger



wall is said to have been solved by the development of biasbrix, a unique shaped refractory. As the name implies, biasbrix are laid up on the bias, one brick overlapping and tying together three other biasbrix in a natural, self-locking construction which gives exceptionally tight joints and a wall of great strength. Owing to this peculiar construction and interlocking feature, walls laid of biasbrix do not loosen up, joints remain tight and heat losses and slag penetration are reduced to the minimum.

Although different in shape, biasbrix lay up as readily as the ordinary straight brick in any thickness of wall from 4½ in. to 27 in. or more, and are equally well adapted to large or small installations. They are particularly well suited for hollow wall construction, where a strong bond is of paramount importance.

Biasbrix is an exclusive product of the General Refractories Company, Philadelphia. Although radically different in shape from the conventional fire brick, biasbrix are available as regular stock.

### Steel Mills Purchase Motors

The Westinghouse Electric & Mfg. Company has sold one 6500 hp. reversing blooming-mill motor to the Illinois Steel Company, and a 4600 hp. motor to the Tata Iron and Steel Company of Punjab, India.

## TRADE NOTES

Announcement is made of the purchase of the Broadway Iron Foundry Company at Cambridge, Mass., by the Barbour Stockwell Company of the same city. The Broadway Foundry, established 1864, was one of the pioneer foundries of Greater Boston. The plant will continue to be operated for the present by the Barbour Stockwell Company with Mr. Robert C. Bird as manager.

\* \* \*

Allis-Chalmers Manufacturing Company, Milwaukee, has opened a new district sales office at Phoenix, Ariz., covering the states of Arizona, New Mexico, and Northern part of the Republic of Mexico. The office is located at 308 Heard Building, with J. B. Cooper as manager. Mr. Cooper's headquarters were formerly in Los Angeles.

A branch office has been opened at San Antonio, Texas, 619 Frost National Bank Building, with Mr. Earle R. Hury in charge. This is a branch of the district office at Dallas.

A branch office is also being opened at Grand Rapids, Mich., Weiss Service Building, with G. C. Culver in charge. This is a branch of the Detroit district office.

\* \* \*

The Combustion Engineering Corporation has specified a Steere arc welded steel purifier for the new low temperature carbonization plant it is building here. It will be erected in the spring by the Semet-Solvay Engineering Corporation.

The purifier will be 28 ft. x 70 ft. x 12 ft. 6 in. in size, and of the elevated type. It will have three compartments and two layers of oxide trays. A gantry crane will handle doors and will also carry an oxide elevator and screw conveyor for filling the box. Spent oxide will be removed through four bottom dump doors under each compartment.

The purifier will be equipped with a 20-in. manifold of Steere welded steel construction and will have 15 Steere gate valves. The capacity will be 4,000,000 cu. ft. of gas each 24 hours.

\* \* \*

The merger of the Andrews-Bradshaw Company of Pittsburgh, Pa., with the Blaw-Knox Company has just been announced. The Andrews-Bradshaw Company is a Pennsylvania Corporation whose main offices are in Pittsburgh, Pa., with representatives in all parts of the United States and foreign countries. The principal product of this company is known as the Tracyfier, a device for thoroughly cleaning steam, gas, air and vapor—and is being widely used in boiler plants, refineries, gas plants, etc.

No change in the organization of the Andrews-Bradshaw Company is contemplated, with the exception that the products of this company will be manufactured in the main plant of the Blaw-Knox Company at Blawnox, Pa. The Andrews-Bradshaw Company will operate as the Andrews-Bradshaw Division of the Blaw-Knox Company.

This merger gives to the Blaw-Knox Company an additional product for the power plant field, in which

the company is already well represented through its air preheaters, standard steel buildings, clamshell buckets, and electroforged steel grating.

\* \* \*

American Arch Company, Inc., of New York announces that Mr. G. S. Carrick has been appointed general manager of the Industrial department. He will have full charge of all matters relating to the company's furnace products—the Type A Unit Supported Wall, the Type C Air Cooled Blocks, the American Arches and other types of walls, roofs or bottoms.

Mr. Carrick has had many years experience in power plant work. After being graduated from Purdue University in 1909, Mr. Carrick served with the Westinghouse Company in the power plant department, later being transferred to the industrial sales department, having charge of sales in the southeastern district.

\* \* \*

The Timken Roller Bearing Company of Canton, Ohio, will occupy spaces Nos. 414-415 at the Mid-West Power Conference at Chicago, February 14 to 18. The company's exhibit will consist of bearings of the type used in railway journal boxes, of the type used on steel mill roll necks, of both single and double row bearings for electric motors, and a general assortment suitable for use on machinery in general.

Those representing the company at the exhibit will be; L. M. Klinedinst, G. D. Thewlis, R. P. Proffitt, R. W. Ballentine, G. W. Curtis, and R. P. Kelley.

\* \* \*

After January 1, 1928, the Pacific coast office of The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., manufacturers of electric motor control apparatus and allied lines, will be handled by their own Pacific Coast sales offices, at 970 Folsom Street, San Francisco; 229 Boyd Street, Los Angeles; 2203 First Avenue, South, Seattle.

The new sales district will be in charge of Mr. Fred H. Oberschmidt, a member of the Cutler-Hammer organization for over 15 years. Associated with Mr. Oberschmidt at the San Francisco headquarters office will be Mr. A. A. Tuffert and Mr. George P. Stone. Mr. Thomas N. Bristow will be in charge of the Seattle office and Mr. Edward G. Nelson of the Los Angeles office.

\* \* \*

Botfield Refractories Company, Philadelphia, Pa., manufacturers of Adamant Fire Brick Cement, announces the appointment of Mr. Ires Prosser as southeastern representative. Mr. Prosser's territory will embrace the entire southeast from North Carolina to San Antonio, Texas. His headquarters will be Atlanta, Ga.

\* \* \*

Charles H. Leinert, president of the Leinert Valve Company, Inc., with offices at 310 South Michigan Avenue, Chicago, Ill., has been appointed district representative in the Chicago district for the Birdsboro Steel Foundry & Machine Company, Birdsboro, Pa.

\* \* \*

The Wellman-Seaver-Morgan Company, Cleveland, Ohio, has announced the removal of their New York office from 522 Fifth Avenue to 30 Church Street, on January 16, 1928.



# NEWS OF THE PLANTS

Spang, Chalfant & Company, through Henry Chalfant, chairman of the board announces a merger of that company and Standard Seamless Tube Company, with a controlling interest in the Oil Well Supply Company. The business of the company will be conducted in the future under the name of Spang, Chalfant & Company, Inc., but will include the entire personnel of the three companies. Spang, Chalfant & Company is one of the oldest manufacturers of butt and lap weld pipe in the country. The Standard Seamless Tube Company is said to be the largest independent manufacturer of seamless pipe in the world. The combined capacity of the company will rank third in the United States in the production of seamless and welded pipe, it is said. The inclusion of the controlling interest in the Oil Well Supply Company will give the combined companies, in addition to their outlets for merchant pipe, a distribution throughout the oil fields, where approximately 90 stores are maintained by the Oil Well Supply Company.

\* \* \*

Struthers Furnace Company has been reorganized as the Struthers Iron & Steel Company, with W. C. Holtzworth as president, J. E. Parker, treasurer; E. J. Tillotson, vice president; Wm. Henderson, secretary. The company produces low phosphorus basic foundry and malleable pig iron.

\* \* \*

Danville Structural Steel Company, Danville, Pa., has been purchased by Charles M. Schwab of the Bethlehem Steel Company. The company was organized early last year and acquired the plant of the Pennsylvania Brake Beam Company. Its products include steel tubing, channel iron, miscellaneous shapes and snow fence. C. Clarence Wymouth will be in charge of the plant.

\* \* \*

Plans have been arranged for moving the fence mill of the Wickwire Spencer Corporation from the east to the Buffalo, N. Y. plant. The step has been taken to favor economies in production.

\* \* \*

Gears & Forgings, Inc., has been organized by a merger of the Fawcus Machine Company, Pittsburgh, the Van Dorn & Dutton Company, of Cleveland; the William Ganschow Company, Chicago and the Ohio Forge Company, Cleveland. F. W. Sinram, president and general manager of the Van Dorn & Dutton Company will be president of the new company, A. F. Cooke of the Fawcus Company, will be first vice president and Wm. Ganschow, second vice president, J. M. Clem of the Ohio Forge Company, third vice president. S. C. Dalbey will be secretary and treasurer. The new organization is in position to control the processes of manufacture of industrial gears from the raw material to the finished products and has the advantages of large scale production and favorable geographical location.

\* \* \*

The absorption of the Trumbull Steel Company, by the Republic Iron & Steel Company, Youngstown,

Ohio, has been approved and through the merger the Republic Company becomes the fifth largest steel company in the United States.

\* \* \*

The Empire Steel Corporation has been organized to merge six sheet mills: The Mansfield Sheet & Tin Plate Company, of Mansfield, Ohio; the Ashtabula Sheet Steel Company, Ashtabula, Ohio; the Thomas Sheet Steel Company, Waddell Steel Company, and Falcon Steel Company, Niles, Ohio, and the Empire Steel Company, Cleveland, Ohio. W. H. Davey, president of the Mansfield Company, was elected president of the new corporation. On the directorate with Mr. Davey are: H. S. Pickands, Pickands, Mather & Company, Cleveland; A. I. Davey, vice president Mansfield Company; C. F. Ackerman, Mansfield banker; C. H. Henkel, Mansfield attorney; M. C. Robinson, director of the Ashtabula Company; Samuel, John, Harold and F. A. Davey, Mansfield; J. D. Waddell, president and R. L. McCorkle, vice president, Waddell Steel Company; W. R. Jenkins, secretary Mansfield Company; A. W. Wheatley, Lima, president Empire Steel Company; E. C. Werner, Delphos, Ohio; C. S. Thomas, chairman of the Thomas Sheet Steel Company; C. F. Smith, Youngstown, temporarily representing W. A. Thomas, president of the Thomas Company, Lloyd Booth, president and Paul Wick, vice president, Falcon Steel Company.

\* \* \*

The merger of the Youngstown Sheet & Tube Company and the Inland Steel Corporation is assured. The new concern will be called the Youngstown-Inland Steel Corporation. James A. Campbell, president of the Youngstown Company will be president. L. E. Block, chairman of the board and P. D. Block, president of the Inland Steel Corporation will be vice presidents. There will be no particular changes in the operations. The ingot capacity of the new company will be about 5,000,000 tons annually.

\* \* \*

The Ziv Steel & Wire Company, Chicago, announces change of officers as follows: G. F. Ziv, president; A. Ziv, chairman of the board; N. J. Hyslip, vice president; M. Foley, secretary; H. E. Ziv, treasurer.

A. F. Brunck has been appointed general sales manager with headquarters in Chicago.

## Cold Heading Steel

Cold heading steel is the grade used for bolts, etc., that have cold formed heads or cold upset parts. It is essential that the steel be of proper analysis and that it be in the proper physical condition as well. The composition usually allowed on ladle analysis is as follows:

Open hearth steel only, carbon .09, mang. .30/45, phos. .025, sul. .045

and it is necessary to keep the grade as soft as possible. Also attention must be paid the proper ingot treatment and to finishing temperatures in rolling and to proper cooling of the finished bars.



Victor Windett, who, since 1917, has been engineer of the gas producer division of The Wellman-Seaver-Morgan Company, Cleveland, Ohio, has been appointed manager of the gas producer division of the company, effective January 1st, 1928.

Mr. Windett is a graduate of the Massachusetts Institute of Technology in mechanical engineering.



Following his college course he became connected with the Illinois Steel Company, Chicago, in operating and engineering work, where he designed and supervised the construction of their ore docks. As the Chicago representative of Julian Kennedy, he superintended the building of the Lake Shore Plant of the Iroquois Iron Company. Later he was resident engineer of the American Coke & Gas Construction

Company in the building of the Otto Hoffman Coke Oven Plant at Maysville, Wis., for the Northwestern Iron Company. He spent sometime as engineer and contractor at New Orleans and in Louisiana on drainage, water, sewerage and levee construction work, and in the Chicago district on various public work, harbor work and bridge work, and on the fourth U. S. Lock at Saulte Ste. Marie, Mich.

During the world-war he supervised the building of open-hearth furnaces at the Watertown, Mass., arsenal for The Wellman-Seaver-Morgan Company, and Sulphuric Acid Plants at Cuba City and at New Diggings, Wis., for the Leonard Construction Company of Chicago.

George L. Pollock, vice president and Treasurer of the Burnside Steel Foundry Company, since its organization, has resigned as of January 1 to become vice president of The Nugent Steel Castings Company, Chicago. Prior to becoming associated with the foundry industry, Mr. Pollock had been with the purchasing department of the Burlington R. R. and later served as purchasing agent of the Wheeling & Lake Erie R. R., and the Chicago & Western Indiana R. R. and Belt Railway Company of Chicago.

\* \* \*

Charles M. Schwab, chairman Bethlehem Steel Corporation was guest of honor at a luncheon given by the American Arbitration Association at the Hotel Astor, New York, on January 5.

\* \* \*

Chas. S. Dyer has resigned as vice president and director of the Shenango Company and as a director of the Lake Carriers Association, the Lake Protective Association and the Great Lakes Towing Company. He will devote his attention to private interests and will maintain an office at 616 Oliver Building, Pittsburgh, Pa.

\* \* \*

Charles J. Brown, previously general superintendent of the Schoenberger works, Pittsburgh American Steel & Wire Company, until it was dismantled in 1925 and since engaged in special work at the company's Cuyahoga works, Cleveland, became superintendent of the wire mill at the Donora works, Donora, Pa., on January 1. C. G. Van Hoesen, assistant superintendent Farrell works, Farrell, Pa., becomes assistant superintendent of the wire mill at Donora and will be succeeded by Albert Eyman formerly assistant superintendent Rankin and Braddock works. L. H. Miller, now at Donora, succeeds Mr. Eyman as assistant superintendent Rankin and Braddock works. Mr. Brown had been superintendent of blast furnaces and assistant general superintendent at the Donora works prior to his transfer to the general superintendency of the Schoenberger works. Before joining the American Steel & Wire Company he had been superintendent of the Zenith Furnace Company, Duluth, Minn.



W. R. Bean, who in August of last year was appointed vice president and consulting engineer of the Grindle Fuel Equipment Company, Harvey, Ill., subsidiary of the Whiting Corporation, has been elected president of the Grindle Company, succeeding R. H. Bourne, retired. Mr. Bean had been for 11 years research engineer of the Eastern Malleable Iron Company, Naugatuck, Conn.

Harry R. Patterson, for 15 years superintendent of the Rockdale works, American Steel & Wire Company, Joliet, Ill., has been made superintendent of the Rankin and Braddock works. He succeeds Edwin H. Broden.

Edwin H. Broden has been made manager of the Pittsburgh district wire mills, American Steel & Wire Company, succeeding C. F. Blackmer recently appointed general superintendent of wire mills. Mr. Broden has been with the company and its predecessors for 33 years.

Earl F. Varnum, employment director of the Commonwealth Steel Company, Granite City, Ill., has been appointed assistant to the general manager. He retains general supervision over the personnel work which is in charge of Milton Allen.

John Gold, chief metallurgist, Weirton Steel Company, Weirton, W. Va., has been made operating manager of the strip and strip sheet mill division, succeeding Frank E. Flynn.

Alexander P. Moore has been elected a vice president of the Pittsburgh Steel Products Company, with headquarters at New York.

David Pride has been made manager of works of the Superior Steel Corporation, Carnegie, Pa. He had been for 10 years assistant general superintendent of the city mills, Carnegie Steel Company.

C. F. Blackmer recently made general superintendent of wire mills for the American Steel & Wire

Company, was the guest of his former associates at a dinner at the Union Club, Pittsburgh, on January 7. E. A. Niven, Pittsburgh district sales manager was toastmaster.

Ralph E. Hough has been transferred from the Lackawanna Mills to the Gautier plant of the Bethlehem Steel Company, Johnstown, Pa., as general superintendent.

Chas. A. Fisher has resigned as president of the Jones & Laughlin Steel Corporation, and will retire from active business.

C. E. Stuart has resigned as president and treasurer and as a director of the Central Alloy Steel Corporation of Canton and Massillon.

B. F. Fairless, vice president and general manager becomes president and a director of the corporation and will continue as general manager.

S. S. French has been made a director and will be vice president and treasurer, and will continue as president of the Berger division.

### Obituary

Thomas Arthur Jones, age 64, manufacturer, died at his home in River Forest (a suburb of Chicago), on January 19, 1928. Mr. Jones was born on December 12, 1864 in Susquehanna County, Pa., and coming to Chicago in 1892, he became associated with the W. A. Jones Foundry & Machine Company, manufacturers of transmission machinery, afterward becoming the managing head. For many years he was secretary of the corporation and later served as president and at the time of his death was vice president.

In 1918 he took over the active management of the Sackett Screen & Chute Company of Chicago, serving as its president and general manager. This business he conducted up to the time of his death.

Mr. Jones was a member of the Chicago Athletic Association, Riverside Country Club, Chicago Machinery Club, Laporte Country Club and of the Masonic fraternity.



## TRADE PUBLICATIONS

The water works pumping equipment of the City of Haverhill, Mass., is described in a four-page leaflet issued by the De Laval Steam Turbine Company, of Trenton, N. J. The city operates two pumping stations, one at Kenoza, and the other at Millvale, both of which were originally equipped with reciprocating pumping units. With a view to increasing the water supply and reducing pumping costs, two electric-motor-driven centrifugal pumps have been installed, one having a capacity of a little over 7,000,000 gal. per 24 hours against 90 ft. head, and the other a capacity somewhat in excess of 6,000,000 gal. per day against 211 ft. head. In the official acceptance tests, these units developed a very high overall efficiency from wire to water.

\* \* \*

The Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., has issued the "Catalogue of Electrical Supplies" for 1928-1930, superseding their catalogue of 1925-1927. This is a cloth bound book of 1,171 pages completely indexed and fully illustrated.

\* \* \*

"Hyatt Equipped Railroad Journal Boxes" is the title of a registered edition published by the Hyatt Roller Bearing Company, of Newark, N. J., a division of General Motors, describing developments in the use of Hyatt journal boxes in connection with railway cars and equipment, and other applications of the Hyatt roller bearings.

\* \* \*

The American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York City, has brought out the seventeenth annual edition for use during 1928 of the "Condensed Catalogues of Mechanical Equipment" including—classified catalogue section, general classified directory of manufacturers, and professional engineering service directory. Price \$5.00 per copy with concessions to members.

\* \* \*

The Silica Gel Corporation, Garrett Building, Baltimore, Md., is distributing a reprint of an article by Edwin H. Lewis, M. A., general manager of The Glasgow Iron & Steel Company, Ltd., from The Industrial Chemist of October, 1927, entitled "The Use of Silica Gel as a Medium for Drying Blast."

\* \* \*

Bausch & Lomb Optical Company, Rochester, N. Y., distribute a booklet describing their large metallographic equipment with cuts from photomicrographs illustrating the recent advancement in the microscopic art in studying metals.

\* \* \*

In connection with their folder describing the Erie City Vortex Furnace for powdered coal, the Erie City Iron Works of Erie, Pa., is distributing a paper by Prof. W. J. Wohlenberg, M.S., M.E., entitled "Some Fundamentals of Water-Cooled Furnace Design."

\* \* \*

The K. S. G. Process for low temperature carbonization of coal is described in an illustrated booklet put out by the International Coal Carbonization Company, 200 Madison Avenue, New York City, a subsidiary of the International Combustion Engineering

Corporation. It contains a description of the plant at Essen and of the products and costs.

\* \* \*

"Krompatch" is the subject of a recent folder by E. J. Lavino & Company, Bullitt Building, Philadelphia, Pa. It covers the various uses of the cement and methods of its application.

\* \* \*

A folder from the National Air Filter Company, 5130 Ravenswood Avenue, Chicago, Ill., features clean air for mill motors. Super-clean air is essential when the ventilation of electrical equipment is concerned.

\* \* \*

Walworth Company, 88 Pearl Street, Boston, Mass., has issued a booklet on brass valves describing the material and construction of the various types which they manufacture.

\* \* \*

Of likely interest to plant managers, department heads, efficiency experts, or any who have to do directly or indirectly with material handling in and about warehouse and factory, is a brochure just off the press dealing with the efficiency and economy of the electric truck and tractor in industry.

This handbook, of 96 pages and some 136 illustrations, is published by The Society for Electrical Development in co-operation with 20 manufacturers of electrical industrial trucks and tractor, storage batteries and accessories, who are engaged in a co-operative market development program.

With a special chapter for each of 16 major industries, this book entitled—"Profitable Application of Industrial Trucks and Tractors in Industry"—is based on a survey of 200 typical plan operations made by a member of the Survey Committee of the American Society of Mechanical Engineers.

For each of the industries, the operating processes and the particular type of truck suited to individual jobs are described. An outline of operating costs together with a tabulation of direct savings effected by employing this means of equipment are given.

## COMING MEETINGS

Feb. 14-17—Midwest Power Conference and Midwestern Engineering and Power Exposition. Chicago Coliseum. G. E. Pfisterer, 53 West Jackson Boulevard, Chicago, secretary.

\* \* \*

Feb. 16-17—American Society for Steel Treating. Semi-annual meeting at Montreal, Que. W. H. Eisenman, 7016 Euclid Avenue, Cleveland, secretary.

\* \* \*

Feb. 21—Annual meeting of the American Mining and Metallurgical Engineers at the Engineering Societies Building, 29 West Thirty-ninth Street, New York City.

\* \* \*

April 3-5—American Oil Burner Association. Fifth annual convention and exposition at Hotel Stevens, Chicago. Leod D. Becker, 350 Madison Avenue, New York, executive secretary.

\* \* \*

April 25-26—National Metal Trades Association. Thirtieth annual meeting at Hotel Astor, New York. J. E. Nyham, secretary, People's Gas Building, Chicago.



## THE STEEL PLANT BRICK MASON

### 250,000,000 Cement Bags

The Bulletin of the International Cement Corporation, New York, says that to replace cloth sacks in the portland cement industry of this country, lost or destroyed annually, would require a strip of cloth 30 in. wide, reaching twice around the world. To make these bags would require labor of 300 men, working 200 eight-hour days in a well equipped factory. There are about 250,000,000 cloth bags in use right now in this industry, and in 1926, 65,000,000 were lost or destroyed. As the value of each bag is 10 cents, this means a loss in one year of \$6,500,000.

### Biasbrix

One of the most difficult problems of fire brick construction, in the opinion of a great many engineers, is the difficulty of making brick stay put under the stress and strain of actual working conditions. There is always the tendency for walls to loosen up and joints to open, resulting in heat losses, slag penetration and eventual disintegration. This problem of a stronger wall is said to have been solved by the development of Biasbrix, a unique shaped refractory. As the name implies, Biasbrix are laid up on the bias, one brick overlapping and tying together three other Biasbrix in a natural, self-locking construction which gives exceptionally tight joints and a wall of great strength.

### Extensive Dolomite Development in New Brunswick, Canada

The demand in world markets for magnesia has given impetus to the quarrying of extensive deposits of dolomite on the lower reaches of the Saint John River of this province. Dolomite or magnesium limestone taken from districts near the city has long been utilized in the limeburning plants on the outskirts of Saint John. This product has been found to contain a high percentage of magnesia according to investigations conducted by H. G. Wilsman, mineralogist of the Natural Resources Department of the Canadian National Railways.

### Air Space Not an Insulator at High Temperatures

For some time there was a general belief that since air is a poor conductor of heat, air spaces built into the walls of boilers, furnaces, etc., would prevent or reduce heat loss through the walls. Messrs. Ray and Kreisinger of the U. S. Bureau of Mines ran a series of exhaustive tests on air spaces used as an insulation and showed that this artifice defeats its own purpose at high temperatures because of the fact that the hot surfaces of the air space radiate heat so rapidly that a greater amount is lost across the space by radiation than would be conducted were the air space to be filled with material of relatively high conductivity such as fire brick. The reason for this is easily seen when we realize that the quantity of heat passing through a portion of a solid wall by conduction depends upon the difference between the temperatures of the two planes limiting the portion of the wall; while the quantity of heat that passes across the air space in the wall depends on the difference between the fourth powers of the absolute temperatures of the surfaces enclosing the air space.



For 13 years Elmer Jackson has been employed in the masonry department of the Follansbee Brothers Company at Follansbee, W. Va. Being superintendent of masons he prefers to appear with the most fitting background.

Such information is hardly necessary to confirm the fallacy of attempted insulation in furnace walls by the use of so-called "dead air space." Besides the intense radiation through air at high temperatures, there is also rapid convection. The average velocity of the molecules in air, at 1100 deg. F., is approximately 60 miles a minute (this calculation can be made from information to be found in many standard texts on physical chemistry); it might be well, therefore, to use the term "live air space" instead of "dead air space."

—Bulletin of the Celite Products Company.

### Mechanical Properties of Silica Products

A paper by A. J. Dale, bears the title, "The effects of temperature on the mechanical properties of silica products," the term "silica product" being restricted to materials containing more than 92 per cent silica. The experimental results suggested that there are two fairly distinct classes of commercial products, for convenience termed Class A bricks and Class B bricks

(Continued on page 291)





## THE STEEL PLANT BRICK MASON

### The Trend of Refractories in 1927

By Stuart M. Phelps\*

Definite progress in the service given by refractories has been effected in recent years. This is clearly shown in the refractory production figures as compared with industrial production of raw materials and commodities. In recent years the consumption of the various refractory materials, as figured on refractories per unit of out-put, has been lower than in times past. This means that either the refractories are of a more suitable nature, or that they are used to better advantage in furnaces of better design and operation. Undoubtedly both conditions are factors in the increased service which is being rendered. In the future, no doubt, both of these phases of development will extend their service to a still greater degree.

Consumers are becoming better acquainted with the properties of refractories as well as their behavior in various positions in furnaces. Engineers and technicians are studying service problems, which so often are of a complicated nature by reason of the many variables in service and of the characteristics of the various refractories.

As a result of these tendencies, more definite and organized conditions are becoming evident both in the use and purchase of refractories. A natural sequence to this development is specifications, which evolve from careful study and observations as to the best type of refractory for a given position in a particular furnace. It would not be logical to expect one set of requirements to cover positions in service which are dissimilar in their nature. In reality specifications have been in use for some time. That is, certain types of brick are required for a definite position in service especially where conditions are severe. Although the requirements are not always set down in black and white, they are, nevertheless, stipulated, and, therefore, form a simple type of a specification. As the consuming and producing interests progress in their branches of the industry, greater use will be made of specifications. It should be borne in mind, however, that an illogical or unpractical specification may do more harm than good. In the development of any specification it is desirable that the engineers of the consumer and

producer co-operate so as to include in it the essential and practical requirements that will make it of real value.

Increased uniformity of products and higher quality have been the aims of manufacturers in modernizing their plants with more efficient and better designed machinery. The reduction of the human element in manufacturing is tending to produce a more uniform brick. This pertains not only to the actual forming of the brick, but also to the firing. It is obvious that the use of the tunnel kiln, for example, would produce more uniformly fired brick. Although tunnel kilns have been used to fire clay brick previous to this year, it has only been with 1927 that definite steps have been made in this country to fire silica brick by this efficient method. The subject of tunnel kilns is now apparently of intense interest to many refractory manufacturers and undoubtedly, in the coming year, an additional number of plants will install them.

No radical change has taken place in the method of forming brick. The percentage of silica brick manufactured by the machine method is steadily increasing. Dry-pressed clay brick are gaining in favor, replacing hand-made and stiff-mud brick in many positions of service. The careful control of raw material by better mining and sorting, and through testing, is of assistance in effecting higher quality of products.

The special refractories such as diaspore, mullite, kaolin and cast materials, have received their share of attention in development and application. Being relatively expensive per unit of refractory as compared with the more usual types, it is desirable to make a careful survey of the conditions of a given service so as to insure their use as being economical. These materials are making steady progress and are relieving the ordinary refractories of some of the more severe requirements previously demanded in certain operations.

Increasing use is being made of the plastic refractories and and worthy high-temperature cements. The plastics of the better grades are finding increasing use in small special linings and are of value in replacing special shapes not readily procurable, as well as in general repair work. A large number of high-temperature cements are on the market, with new ones continually coming and going. In spite of the confusion caused by so many cements claiming such unusual and

(Continued on page 291)



STUART M. PHELPS

\*Senior Industrial Fellow, Refractories Fellowship, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.





## THE STEEL PLANT BRICK MASON

### Human Relations

Measure of the progress made in the improvement of human relations in industry, emphasized by Charles M. Schwab as of greater significance than mechanical development, is reflected in a survey of the growth of works councils in American industry by the department of manufacture of the Chamber of Commerce of the United States.

Nearly a million and a half employees in American industry, the review discloses, are now represented by councils through which they have a voice in management and in the solution of problems by which they are immediately affected.

"A clear recognition of the fact," the department of manufacture says in its report, "by employer and employee of the simple and fundamental truth that in all matters pertaining to production their interests are parallel will assist greatly in overcoming misunderstandings. There can be no lasting solution of a disagreement until all facts are frankly presented.

"Industry has needed and has searched for some method, some way, some means of bridging these gaps in human relationships in modern and expanding business. Various plans and movements have been proposed and instituted towards this end.

"Employee representation is just one of the devices which has been introduced with the purpose of overcoming the lack of personal touch, misunderstandings and the attendant results between management and men."

The report discloses the methods followed in establishing works councils and the difficulties encountered, and presents in summarized form information gathered from industrial concerns which have operated under some form of employee representation. Copies of the report may be obtained from the Department of Manufacture of the National Chamber.

### Looking Back at 1927

Rapid strides were taken by the Bell System during the past year in extending the range of telephone communication to bring other nations within speaking distance of American telephone users. Early in the year, commercial telephone service between New York and London became a fact. The service was gradually extended so that, within a few weeks, practically all points in both the United States and Great Britain were brought within the range of communication by telephone. Subsequently, parts of Cuba and Canada were also brought within the limits of this service.

While it has long been possible for American telephone users to talk to most Canadian points, the facilities for telephone communication across our northern boundary were augmented, during 1927, by the establishment of a direct connection between the telephone lines of the Bell System in the United States and the telephone system of Saskatchewan, Canada. New aerial wire lines, connecting Bismarck, N. D., and Saskatchewan's capital city, Regina, completed the work begun years ago, of connecting the Bell System directly with all the more important Canadian telephone systems.

On September 29, President Coolidge and President Calles formally opened the new telephone line which

brought the principal cities of Mexico into voice communication with the United States. The circuits in Mexico were constructed by the Mexican Telephone & Telegraph Company, an associated company of the International Telephone & Telegraph Corporation.

### Mechanical Properties of Silica Products

(Continued from page 287)

respectively. Conversion during kiln firing of Class A bricks produced mainly cristobalite, but in Class B bricks a considerable proportion of tridymite is present. Three peculiarities are noticeable when testing a Class A silica brick under five different static loadings (75, 50, 30, 18, and 4 lb. per square inch). The curves obtained, considered collectively, seem to offer a fairly complete explanation of the causes of failure under stress, thermal and mechanical, at low or high temperatures, of a large class of silica products. The first peculiarity is an accelerated rate of thermal expansion which occurs during the low-temperature range (100 deg. to 350 deg. C. under test conditions). This is attributable to sudden inversions of tridymite and cristobalite. The actual recorded vertical expansions within this temperature range are governed by the magnitude of the applied loading. Generally speaking, the greater the load the less the low-temperature inversion-expansion in the direction of the applied stress. The second peculiarity in these curves is the gradual and increasing difference between the rates of vertical thermal expansion under different loads at temperatures above approximately 900 deg. C. The third peculiarity appears in the final portions of the curves, especially when comparing the 75-lb. and 4-lb. test results. Between 1450 deg. and 1500 deg. C., and onwards, the test-piece under a 4-lb. per square inch loading shows an increasing rate of "thermal expansion" (short for "vertical thermal expansion under load"), whereas under a 75-lb. per square inch loading, "thermal expansion" is retarded at about the same temperature (1480 deg. C.) as it was accelerated under the 4-lb. per square inch stress.

Considering jointly the five curves, it can be concluded that under the imposed conditions (of test), the higher the load the less the low-temperature and high-temperature local expansions, and also the lower the temperature at which vertical expansion ceases.

—Chemistry and Industry.

### The Trend of Refractories in 1927

(Continued from page 288)

mystic properties, the average consumer is beginning to evaluate the merits of the more suitable types, applying them with good returns.

A large number of technical studies have been made in the past year, most of which are of a very practical nature, being of direct value to the industry.

The trend of test methods is toward the duplication of actual service conditions, so as to supply data that can be applied more directly to refractories in service. The relations among the user, the producer, and the technician have been brought closer and will surely continue so to the advancement of all phases of the industry.





# SAFETY FIRST IN THE STEEL PLANT

## Steel Corporation Makes Notable Record

By Sidney J. Williams\*

The United States Steel Corporation, employing both men and women, has reduced its accident rate by 80 per cent, saving over 300,000 persons from injury in the last 13 years and saving for the company more than a million dollars a year over and above the cost of the safety activity. The Du Pont Company has reduced its fatality rate to only one-seventh of the original figure. Plants employing thousands of men have found it possible to go for two or three months at a time without a single injury causing absence from work.

## The Safety Problem in Industry

By W. H. Cameron†

Because the industrial safety problem is essentially a matter of dollars and cents, many an employer has been inveigled into taking an interest in its solution to save the compensation imposed upon him by law. Employers and others have wrangled among themselves for years as to whether the approach should be from the economic standpoint or the natural assumption by the employer that the stopping of accidents is his humanitarian duty. There is no doubt in my opinion that the problem involves both factors. The altruistically minded employer satisfies his conscience and incidentally fattens his pocketbook and the economist sees the difference in the bank balance at the end of the year and, if he will look closely, he will notice fewer maimed and missing persons among his workers than formerly.

The safety problem in industry is to reach 196,000 employers in the United States with the message that accident prevention will bring a larger return in money saved; greater soul satisfaction and more real public service rendered than any other element of his business. But, if the assets are obtainable through constructive safety activities why are so few employers giving genuine attention to the accident problem?

\*National Safety Council.

†Managing director, National Safety Council, Chicago.

## Foundries Have High Accident Rate

The accident frequency rate in foundries in 1913 was 72.8, while in 1926 it was 60.6. The accident severity rate in foundries in 1913 was 3.7, and in 1926, 3.3.

Attention has been called to this situation from time to time in these annual reviews, and it is distinctly disappointing that, taken as a whole, foundries are so much out of step with the other departments of the industry.

## Every Foreman a Safety Director

By F. J. O'Connor‡

What is the foreman's job?

Is it wholly production? Not necessarily, but production is one of the primary essentials of his job, and this means quality, workmanship, delivery within the specified dates, low costs, at a profit, and with a sensible regard for the physical upkeep of the plant and equipment, and for the health and safety of all employees. And today the safety of all the employees is irrevocably tied into production just as much as low costs, reduction of overhead, accurate timekeeping, layout work, or estimating jobs. Therefore, if the foreman is to be universally successful, he must recognize safety as a part of his job; and as his gang grows larger, as his work becomes more diversified, his hazards will increase, and in meeting and overcoming these hazards he becomes a directing factor in the safety policy of the plant.

Safety, then, is an integral part of the job, and if the foreman is to put over the plant manager's program, he must believe in safety and recognize its worth.



C. L. Peake is an active participant in the affairs of the National Safety Council in which organization he is chairman of the Poster Committee. With the American Radiator Company, he is director of Industrial Relations.

## Anthony Brady Medals Awarded

Three Anthony N. Brady Memorial Medals for outstanding accident prevention and health promotion work on electric railways, for the year ended December 31, 1926, have been awarded to the Louisville (Kentucky) Railway Company, The El Paso (Texas) Electric Company and the Tide Water Power Company of Wilmington, N. C. The Pittsburgh Railways Company received honorable mention and was voted a certificate. Announcements of the awards were made jointly today by the American Museum of Safety and the American Electric Railways Association.

‡E. I. du Pont de Nemours and Company.